

New Scientist

WEEKLY 4 May 2024

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Climate, health and more as
nation goes to the polls

COMPLEX DARK MATTER
The search for the universe's
secret ingredient

NUCLEAR SWEET SPOT
Key milestone reached on
the way to fusion power

THE END OF

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~~HAZELNUT~~ ~~EGG~~
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NS Live

Gravity rules

Why do the electric charges of the electron and proton cancel out exactly, making atoms electrically neutral and allowing gravity to shape the cosmos? Hear Frank Close guide you into the subatomic world, exploring whether matter is unstable and if the material universe is already decaying. This talk will be held at New Scientist Live on 12 October at London's ExCeL Centre.

live.newscientist.com

Tour

Dinosaurs and Hoodoos: Alberta, Canada

Join palaeontologist and geologist Jon Noad on a whistle-stop tour of prehistory in southern Alberta. Traverse the multi-hued canyons and wind-sculpted hoodoos of the iconic badlands and check out one of the world's premier dinosaur museums in nearby Drumheller. This three-day tour starts on 23 July and costs £1599.

newscientist.com/tours

Podcast

Weekly

This episode, the team explore how new devices can assemble themselves using the quantum effects of empty space. A deep dive into the fascinating research on how animals communicate takes centre stage, and what will the results of India's elections mean for climate change? Plus, the exciting news that, after months of silence, Voyager 1 is emitting signals again.

newscientist.com/nspod

Tour



ELENA ELISSEEVA/ALAMY

Alberta badlands Visit a site filled with incredible dinosaur fossils

Newsletter



SCENICS & SCIENCE/ALAMY

Root manoeuvres Secrets of the underground lives of plants

Video

Tree of life

Genomic data from more than 9500 species is being used to compile a new tree of life that fills in the evolutionary relationships between groups of plants and fungi. The project is led by biologist Bill Baker at London's Kew Gardens. By identifying new connections, his team plans to piece together the origins of flowering plants and inform future conservation efforts.

youtube.com/newscientist

Newsletter

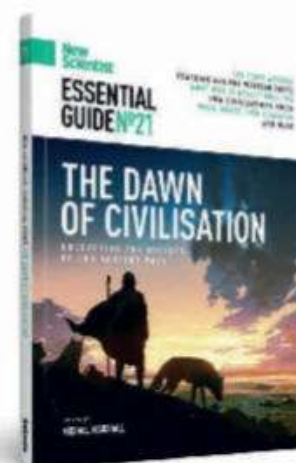
Wild Wild Life

We all know that plants have roots, yet their subterranean lives are somewhat mysterious. Penny Sarchet shares seven root secrets that you may not know, including how to grow plants in space. She also tells us about a diminutive Andean deer, one of Earth's most remote islands and gesturing among Japanese tits.

newscientist.com/wild-wild-life

Newsletter

“They managed to grow chickpeas in lunar soil by adding worms”



Essential guide

Where are the origins of humanity? When did civilisation begin and what does the future of society hold? Uncover the secrets of the past in this *New Scientist Essential Guide* covering all that we know about the arc of human ingenuity. Now available to read in the app or buy in print from our online shop.

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Discovery Tours NewScientist

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Each day, you will explore beautiful landscapes as you walk for around 4 hours discovering the region, accompanied by experts who will bring the landscapes to life.

This tour is led by a Blue Badge-accredited guide, Sophie Campbell. The group will also be joined by Emily Wilson, former *New Scientist* editor-in-chief, for two days to explore Cerne Abbas. In addition, enjoy talks from the directors of the Wiltshire Museum and Salisbury Museum about their archaeology collections.

Find out more at
[newscientist.com/tours](https://www.newscientist.com/tours)

Highlights include:

- › **Delightful walking tours around several prehistoric sites, including the UNESCO World Heritage sites of Stonehenge and Avebury.**
- › **Joined in Cerne Abbas by former editor-in-chief of *New Scientist* Emily Wilson, who will lead a guided walk around the prehistoric landscape.**
- › **Exclusive private dinner at the Wiltshire Museum, accompanied by the museum's director, David Dawson.**
- › **Behind-the-scenes tour of the Prehistory Galleries at the Wiltshire Museum.**
- › **Exploring the pre-eminent earthworks of Maiden Castle and Old Sarum.**
- › **Talk from the director of the Salisbury Museum offering an insight into what life was like during this period.**



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Look to the future

The next leader of India should grab the chance to play a key role in our climate fight

INDIAN readers make up a growing part of *New Scientist's* audience – little surprise given the nation's interest in and affinity for science and technology. The same is true more widely, with growth and development seeing India surge to become a major world power.

At the turn of the century, India ranked 13th in the world for GDP, fewer than 60 per cent of its citizens had electricity and it had launched a handful of satellites to orbit. As the nation goes to the polls this month, it does so as the world's fifth largest economy. Nearly its entire population has electricity and it has sent uncrewed missions to the moon and Mars. In the next few years, India is expected to rank third for GDP, behind the US and China, and to launch its first crewed spacecraft.

Much of this rise is due to sheer demographics. Last year, India overtook China to become the world's most populous country. But the policies of Prime Minister Narendra Modi, who is widely expected to win a third term, have clearly played a role in India's fortunes. In our

"It is a relief that climate science and the need for mitigation aren't up for debate in India"

special report, we examine Modi's record on key issues including climate change (see page 8), health (page 10) and other areas of science and technology policy.

While India's approach to climate change is far from perfect, it is at least a relief that the basic science and need

for mitigation aren't up for political debate. The same can't be said for elections taking place elsewhere. In the US, Donald Trump plans to dismantle environmental regulation should he win the presidency in November, which would produce an extra 4 gigatonnes of emissions by 2030, according to policy website Carbon Brief. Meanwhile, the UK's ruling Conservative party, which is expected to lose the country's upcoming general election, continues to push back against environmental policies.

All this means that whoever wins India's election should grab the chance to play a key role in global climate negotiations. The nation's growing power means that soon we will all be forced to sit up and pay attention. ■

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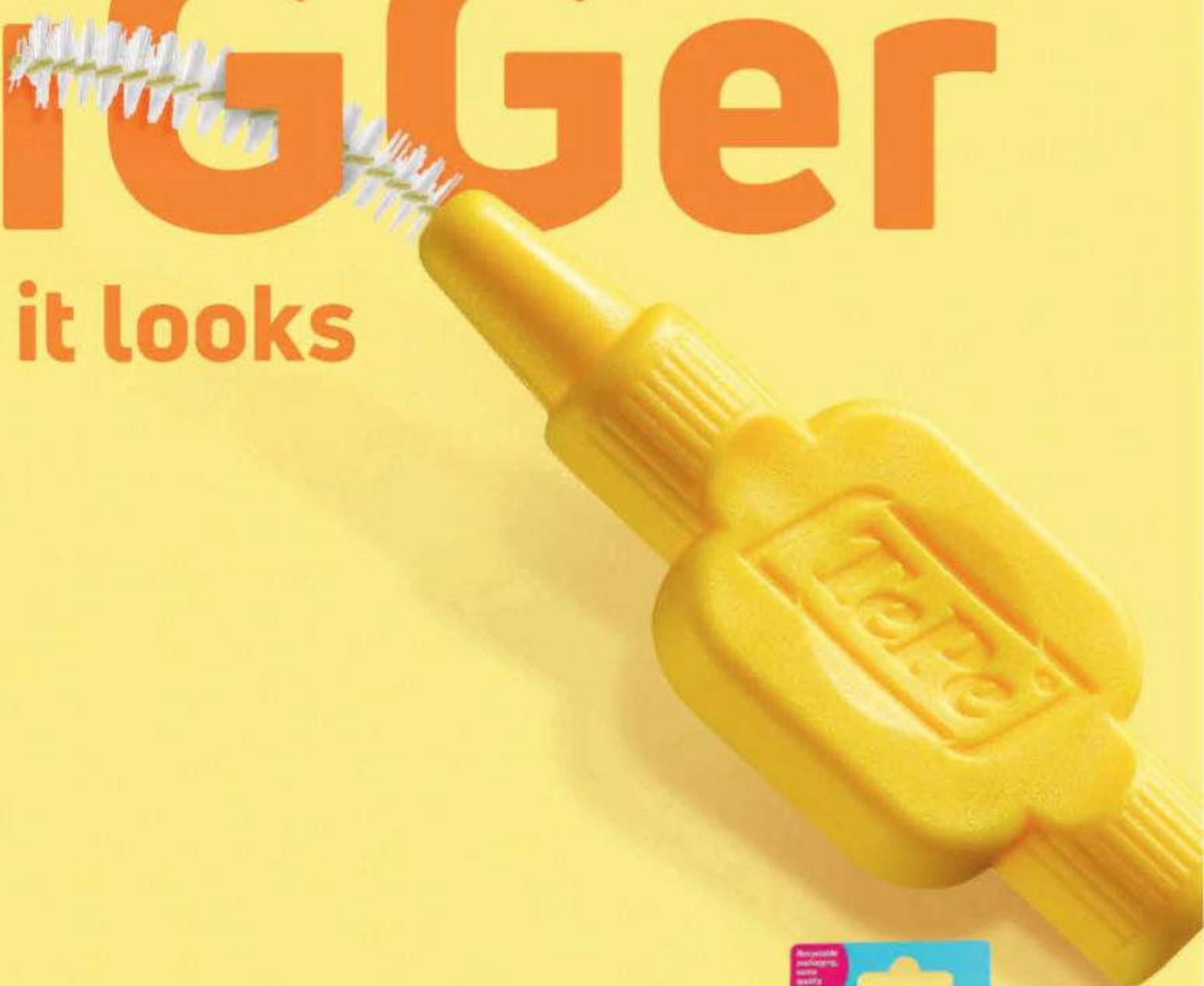
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Beating the habit

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Astronomy

The Horsehead Nebula's fluffy top

This is the sharpest image yet of the curved wall of gas and dust marking the top of one of the most distinctive objects in our skies: the Horsehead Nebula. Above it – captured in incredible detail in infrared by the James Webb Space Telescope – you can see distant stars and galaxies. The nebula is thought to have formed from a collapsing cloud of interstellar material and is illuminated by a nearby star.

ESA/WEBB, NASA, CSA, K. MISSEL (UA) AND A. ABERGEL (IAS/UPs, CNRS)

Climate change

Is India ready to be a climate leader?

As the world's third-largest emitter of greenhouse gases, India's climate policy will shape the fate of the planet. But developing its economy while keeping emissions down will be tough, says **James Dinneen**

"THE entire world is watching us," said India's prime minister, Narendra Modi, in a speech at the COP28 climate summit in Dubai late last year. "Mother Earth is looking toward us to protect her future. We have to succeed." This call for climate action was meant to be a global one, but it could have applied to India alone, as the world's most populous country increasingly sets the course for our climate future.

India is now the world's third largest annual emitter of greenhouse gases after China and the US, having overtaken the European Union just last year. Under Modi's government, India has also taken steps to rein in these rising emissions while simultaneously addressing widespread energy poverty.

Renewable energy is booming on the subcontinent. There is growing adoption of electric vehicles – especially two-wheelers – and there are ambitious plans for it to become a green hydrogen powerhouse. With Modi's Bharatiya Janata party (BJP) expected to win India's election, which saw polls open on 19 April with results due on 4 June, the question is what he will do next.

Spiralling demand

India's path to net-zero emissions remains fraught with difficult choices, from how to supply rapidly rising demand for energy while transitioning away from coal power to the risk of a green trade war with China. While India is only responsible for about 3 per cent of the historical emissions driving climate change, its modern emissions mean the course it takes will prove critical if the world is to succeed at avoiding the most dangerous consequences of warming.

R: REBECCA CONWAY/GETTY IMAGES; BELOW: MONEY SHARMA/AFP VIA GETTY IMAGES



Solar power capacity has increased hugely in India in recent years

A girl burning raw coal to make it saleable on the outskirts of Dhanbad



Modi's climate record began in 2015, just a year after he first came to power, when India joined the Paris Agreement, the global pledge to hold global warming well below 2°C above pre-industrial levels. Since then, Modi's administration has become the first Indian government to set specific national climate targets. The main one, announced in 2021, is for India to reach net-zero emissions by 2070. That is a decade slower than China's net-zero target and two decades behind the US, but many see this as justified given India's small share of past emissions.

India's slower approach to decarbonisation also reflects the fact that its per capita emissions are low, at less than half the global average. These are even lower among India's vast rural population, many of whom lack access to sufficient energy. "The people that don't have access to power right now are not responsible for climate change," says Nishtha Singh at the Asia

Society Policy Institute, a think tank in New Delhi.

We can expect India's emissions to grow as more people gain access to energy and use more of it: under current policy, the International Energy Agency (IEA) projects a 50 per cent rise in

"The people that don't have access to power right now are not responsible for climate change"

India's emissions by 2040, enough to entirely offset the expected decline in Europe's emissions over that period. One quickly rising source of demand is the need to power air conditioners amid rising temperatures. The scorching heat as voters now head to the polls has power operators firing up additional coal and gas generation to meet expected demand.

In the next two decades, the IEA estimates that India will have expanded its power capacity by the equivalent used across the EU today. To do that while limiting emissions, Modi has promised to build renewable energy at a rapid clip. In 2021, he pledged to build 175 gigawatts of renewable energy capacity by 2022 and 500 gigawatts by 2030. India missed the 2022 target, but it has built a record amount of renewable capacity since then. This now makes up just under a third of India's total capacity, although progress varies widely between states.

Solar in particular has boomed. Between March 2023 and March 2024, about 15 gigawatts of solar capacity came online – a record amount. However, 50 gigawatts of additions will be needed each year to reach the 2030 renewable target.

As in other countries, a lack of energy storage needed to integrate more intermittent sources into the grid is a major bottleneck, as

are the improvements needed to the grid, says Madhura Joshi at E3G, an energy think tank. Negotiating land availability for building renewable energy is a serious constraint in densely populated and democratic India. Access to finance is also more expensive than in higher-income countries.

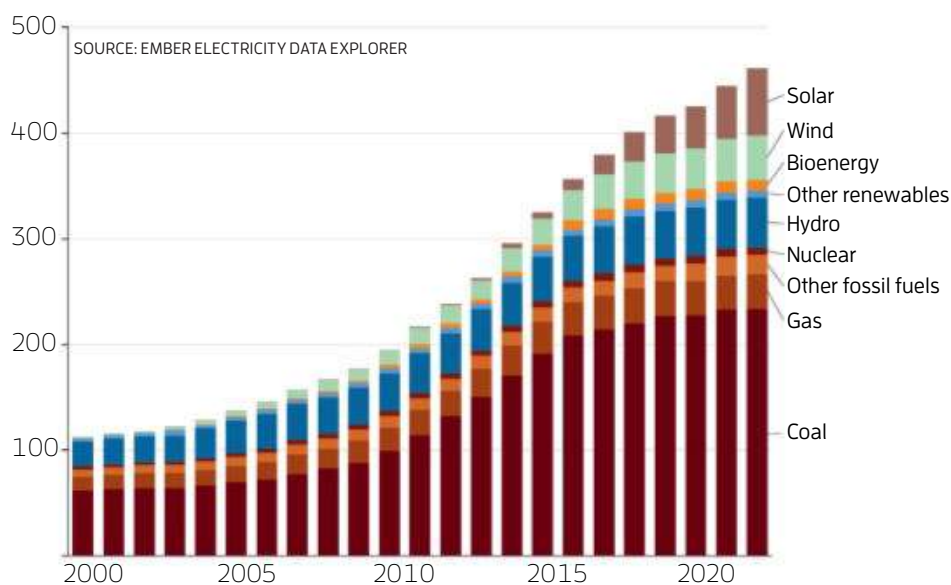
“I think the biggest challenge is availability of funds,” says Singh. A report from Ember, a UK think tank, found that India or international sources need to invest an additional \$100 billion over the next eight years for the country to stay on track with its net-zero scenarios.

Availability of materials is also an issue. So far, India’s solar boom has relied heavily on imported solar panels from China, but tariffs spurred by border issues and other tensions between the two nations have made those more expensive to obtain. India has sought to establish a domestic solar industry, to mixed success.

Another challenge is managing the consequences of the energy transition for India’s poorer, coal-rich east and the country’s prosperous south and west, where

India’s changing energy mix

The proportion of India’s installed energy capacity in gigawatts coming from renewable sources is climbing, but the country is still heavily dependent on coal



most of the new renewable energy is being built. As coal is eventually phased out, states in the east will require more support, says Singh. “We need to rehabilitate the people who have been dependent on coal for so long.”

For the moment, however, India’s coal industry looks set for a robust future. According to a recent Global Energy Monitor report, India is second only to China in new coal power under

consideration, with 46 gigawatts planned (China has 268 gigawatts in the pipeline). Modi’s administration approved those plans and has also extended the life of many coal plants. In the past year, India produced a record nearly 1 billion tonnes of coal. “Coal is something I think we are going to live with at least to 2040,” says Singh.

Other options that have helped the US and EU reduce

coal generation, such as liquefied natural gas, are likely to be too expensive for India, says Joshi. “India’s transition is coal to clean, versus coal to clean via gas.”

But there is debate among energy experts in India about how much new coal power generation is needed to meet rising energy demand, says Neshwin Rodrigues at Ember. A combination of renewables, storage and existing plants running at full capacity may be enough, but the challenge is meeting peak energy demand at night when people are at home and solar generation is low, he says. “How does a politician answer for peak shortage and still garner support for renewables?”

Heatwaves in both 2022 and 2023 led to power shortages, prompting announcements from politicians about plans for new coal plants. Many of those schemes may be scrapped, but we won’t know until both the election and the summer heat are through. As ever, the long-term demands of tackling climate change can be at odds with short-term political horizons. “You don’t want a power crisis to take place in an election year,” says Joshi. ■

Technology

Deepfakes may have a big influence on India’s election

ARTIFICIAL intelligence is enabling India’s politicians to be everywhere at once in the world’s largest election by cloning their voices and digital likenesses.

Even dead public figures, such as politician and actor Jayaram Jayalithaa, are getting digitally resurrected to canvass support. It is shaping up to be the biggest test yet of democratic

elections in the age of AI deepfakes.

India’s election has meant booming business for Divyendra Singh Jadoun, whose company The Indian Deepfaker uses AI techniques to create special effects for ad campaigns and Netflix productions.

His firm is handling more than a dozen election-related projects, including creating holographic avatars of politicians, using audio cloning and video deepfakes to enable personalised messaging en masse, and deploying a conversational AI agent that speaks in the voice of a political

candidate during calls with voters.

“For the first time, it’s going to be happening on a large scale,” says Jadoun. “Even we don’t know what impact it will have.”

For example, an AI-generated avatar of India’s prime minister, Narendra Modi, speaks to voters by name in WhatsApp videos.

The AI-created content tends to present campaigners positively, says

“An AI-generated avatar of Prime Minister Narendra Modi speaks to voters by name in WhatsApp videos”

Joyojeet Pal at the University of Michigan in Ann Arbor. Jadoun says his company turned down about 100 election-related jobs that were “unethical”, such as creating false deepfake videos intended to harm the images of political figures.

But Jadoun points out that anyone can make lower-quality deepfakes online within minutes. The challenge is whether the Election Commission of India – which is working with tech firms to address disinformation – can police them and ensure that the election remains fair, says Pal. ■

Jeremy Hsu

Public health

The world's largest medical system

In the past 10 years, Prime Minister Narendra Modi has worked to improve well-being in India, but much more progress is needed to look after 1.4 billion people, says **Grace Wade**

AS THE most populous country on the planet, India's healthcare policy shapes the well-being of more than 1.4 billion people. During Narendra Modi's decade-long tenure as prime minister, the nation has started various initiatives to boost public health, and yet its medical system still falls short of meeting needs.

Preventable illnesses like tuberculosis and diarrhoeal diseases remain leading causes of death, and chronic conditions such as heart disease and cancer are on the rise. Can this be turned around?

Low healthcare spending is partly to blame for poor outcomes. In 2020, this was equivalent to less than 3 per cent of the country's GDP. Other lower-income economies such as China and Mexico spent roughly the equivalent to 6 per cent of GDP on healthcare whereas the US and UK were at almost 19 per cent and 12 per cent, respectively.

"Part of it is health has never been a political topic in India," says Manoj Mohanan at Duke University in North Carolina. For example, less than 1 per cent of voters cited healthcare as their top concern in the 2019 election.

Instead, development and anti-corruption are popular concerns, leading Modi's government to focus on reforms such as reducing poverty, improving education and expanding infrastructure.

All these indirectly affect health, even if they aren't captured by healthcare spending statistics. "If you think of health broadly, it has a lot to do with social determinants of health," says Anuska Kalita at Harvard University.

One such project is Modi's sanitation initiative, called the Swachh Bharat Mission. Between 2014 and 2019, the proportion of rural households with access to a toilet increased from 39 per cent to

PUNIT PARANI/PEAP/GETTY IMAGES



A woman gets a coronavirus jab at a covid-19 vaccination centre in Mumbai

"The joke is we have 6000 governments in India, so I guess we also have 6000 different health systems"

1.4 billion

The size of the population of India

< 3%

Proportion of the country's GDP that is spent on healthcare

39%

Share of rural households with access to a toilet in 2014, when Narendra Modi was first elected. In 2019, the figure was 95 per cent

more than 95 per cent. This has cut India's rates of open defecation, which is associated with the spread of diarrhoeal disease, although it remains common.

The government has also added 50,000 kilometres of highway over the past nine years, which has improved accessibility to clinics and hospitals. "If you look at the drop in maternal mortality, India has done phenomenally well over the last few years, and a lot of it [probably] has to do with just having the road infrastructure so that a woman can get to a hospital when she's in labour," says Kalita.

That isn't to say Modi has had no specific healthcare policies. The most significant initiative is Pradhan Mantri Jan Arogya Yojana (PM-JAY), dubbed Modicare.

Launched in 2018, it provides low-income households with roughly \$7100 – almost double the average household income of \$4300 – to pay for hospitalisations for specific issues. About 40 per cent of India's population – roughly 500 million people – qualify for PM-JAY, making it the largest public health insurance scheme in the world.

Yet not everyone eligible for PM-JAY uses it. Only 62 per cent of respondents were aware it existed in a survey conducted between 2019 and 2020. Of those, less than 80 per cent understood their eligibility for the scheme.

Uptake is also complicated by healthcare being a state-level responsibility in India. As a result, adoption of PM-JAY varies, with some states opting out entirely. "The joke is we have 6000 governments in India, so I guess we also have 6000 different health systems," says Arnab Mukherji at the Indian Institute of Management Bangalore.

PM-JAY also only applies to hospital care. This deters people from seeking help earlier, when a condition may still be prevented or easily treated with low-cost interventions, says Kalita. On top of this, local health centres are often understaffed and undersupplied, says Mukherji.

Modi's government also hasn't addressed problems about quality of care. "During covid, the vast majority of healthcare providers in the country were writing prescriptions that made no sense," says Mohanan, such as for antibiotics that wouldn't work against a viral infection.

In some ways, the government has exacerbated problems by promoting unsubstantiated traditional medicines, which Modi sees as a way of furthering India's global influence.

"Our traditional medicine is a repository of hundreds of years of accumulated knowledge," he said in 2022, at a ceremony to mark the construction of the World Health Organization's Global Centre for Traditional Medicine in Jamnagar, due to be finished this year. As India grows on the international stage, such views have global ramifications. ■

Can India secure its future by building a powerful computer chip industry?

Matthew Sparkes

INDIA'S prime minister, Narendra Modi, has set a target for the nation to become one of the world's five biggest computer chip manufacturers by 2029, from a base of almost nothing, as part of the country's transformation into a leading global economy. With the rise of artificial intelligence and unstable geopolitics creating a global scramble to build chip factories, how likely is it that India can compete?

Rakesh Kumar at the University of Illinois Urbana-Champaign says there are two main drivers for countries seeking semiconductor self-sufficiency. The first is a realisation, sparked by shortages, that chips are vital to a nation's security and industry. The second is a desire for a slice of an industry worth \$526.9 billion last year.

Currently, Taiwan makes 68 per cent of the world's chips. The threat of a Chinese invasion of Taiwan has sparked global panic and a wave of investment.

"Everybody is foreseeing different kinds of geopolitical games," says Kumar. Whoever has ownership of chip manufacturing can use it as leverage, he says.

One approach is attracting foreign investment and a share of existing chip manufacturing – Apple is considering moving a quarter of iPhone production from China to India by next year, for instance. But true silicon independence will require an infrastructure of supporting suppliers and skilled workers, along with large and continuing investment, says Kumar.

Even with massive government support, Indian chip factories may struggle to be competitive at first, lacking the efficiencies and scale of a mature industry. "Who's going to buy the Indian chips? And who's going to continue buying these for the five or 10 years it may take to become cost competitive?" asks Kumar. If India wants to grow its industry, it may have to bring in



PRADEEP GAURS/SHUTTERSTOCK

India plans to pursue an older form of chip technology

legislation requiring local firms to use local chips, he says.

One thing in India's favour, says Kumar, is that it isn't aiming to compete with the cutting edge of the industry. The goal is to boost production of 28 nanometre chips, which are used in cars and household appliances rather than computers or smartphones

and rely on manufacturing techniques that date back to the early 2000s. "These are not the sexy chips," says Kumar. "But there's a big market."

"We're going all in. Only time will tell how big this thing becomes in the future"

John Goodenough at the University of Sheffield, UK, says India already has some 125,000 workers, making up 20 per cent of the world's chip design workforce, but it will need prolonged investment in other parts of the supply chain. "It depends on how deep their pockets are and how long a game they play," he says.

Awanish Pandey at the Indian Institute of Technology in Delhi is hopeful the country can make a success of the scheme. "We're going all in," he says. "Only time will tell how big this thing becomes in the future." ■

Space flight

How India has slowly become a major player in space

IF INDIA seems a latecomer to space flight, it is only because the country's space agency has been growing slowly for decades, catching up with the original major players.

When the Chandrayaan-3 spacecraft managed the first ever soft landing near the south pole of the moon in 2023, it was a triumph for the Indian Space Research Organisation (ISRO) and a sign that the agency's way of operating makes it capable of great things.

Its strategy was championed in the 1960s by Vikram Sarabhai, often considered the father of the



ISRO

Indian space programme. He rejected the idea that the country had to work through every stage of learning how to do space flight, instead insisting on "leapfrogging", using knowledge gained by other

The Chandrayaan-3 mission lifted off in July 2023, headed for the moon

nations along with expertise developed at home.

"[ISRO has] done a great job of absorbing technologies from different countries and stitching them together to make something that's uniquely Indian," says Itty Abraham at Arizona State University.

Chandrayaan-3 is a perfect example of this. ISRO has stated that the budget for the mission was only £60 million (\$74 million), less than the cost of a commercial plane and astonishingly low for a spacecraft. This was enabled to some degree by the use of off-the-shelf parts

alongside custom-built ones, as well as contracts with private firms for some development and manufacturing.

The involvement of private companies is a change heralded by Narendra Modi, India's prime minister since 2014. "Where Modi has made a difference is that he has encouraged the private sector to step in in a way that is very unusual for Indian government programmes," says Abraham. ISRO didn't respond to a request for comment.

Because of the prestige India has garnered with ISRO's success, the result of its current election is unlikely to change the organisation's direction, whoever wins, says Abraham. ■ Leah Crane

Medicines can help gambling addiction

The drugs nalmefene and naltrexone show promise for treating compulsive gambling

Clare Wilson

TWO medicines usually given to people who are addicted to opioid drugs also help with compulsive gambling. The finding suggests there may be similar brain circuits involved in behavioural addictions as those that cause drug addiction.

Addiction is usually thought of in the context of people who can't stop drinking alcohol or taking certain drugs. A large group of these drugs are those that act via the opioid receptors in the brain, such as heroin or fentanyl. This causes the release of a brain signalling chemical called dopamine, linked with feelings of reward.

Various medicines have been developed to help people who are addicted to opioids, which work by binding to the opioid receptors and blocking the effects of the drugs. These treatments have also been investigated to see if they could help people who experience other kinds of addictions.

When it comes to gambling addiction, the only help usually offered is talking therapy, which doesn't work for everyone.

Some randomised trials have

looked into the effects of opioid-blocking medicines for people who can't stop gambling, as well as some other therapies, such as a medicine given for schizophrenia.

Now, Konstantinos Ioannidis at the Southern Health NHS Foundation Trust in Hampshire, UK, and his colleagues have carried out an analysis of all randomised trials comparing such medications against

Gambling can activate the same brain reward pathways as some drugs

placebo treatments among people with gambling addiction.

They have found that the two most effective ones were a medicine called nalmefene, usually given to people who have taken an overdose of opioids, and one called naltrexone, used long term to help those who take opioids keep off the drugs.

An opioid-blocker called naloxone that is commonly used to reverse opioid overdoses didn't work, probably because its effects are too transient, the authors write in their paper. The schizophrenia

treatment, olanzapine, also turned out to be ineffective ([medRxiv, doi.org/mtdj](https://doi.org/medRxiv/doi.org/mtdj)).

Despite the medications showing promise for treating gambling addiction, people on the two most effective opioid blockers were more likely to stop taking their allotted doses than people in the placebo groups, probably because of side effects, which include nausea and dizziness.

"Given the limited number of treatment options identified in the current [analysis], and the high public health priority of gambling disorder, further large-scale clinical trials are urgently needed," the researchers write.

Barbara Sahakian at the University of Cambridge says the two medications may work because compulsive gambling involves similar brain pathways as those involved in opioid addiction.

"Gambling may start in an impulsive and sensation-seeking way," says Sahakian. "The exciting experience and the wins activate the reward system in the brain and increases the pleasure chemical in the brain, dopamine." ■



SHUTTERSTOCK/IVASHSTUDIO

Technology

Hospital AI that flags raised risk of death helps save lives

AN ARTIFICIAL intelligence system has shown it can save lives by warning physicians to check on patients whose heart test results indicate a high risk of dying. In a randomised clinical trial with almost 16,000 patients, the AI reduced overall deaths among high-risk subjects by 31 per cent.

"This is actually quite extraordinary," says Eric Topol at the Scripps Research Translational

Institute in California, who wasn't involved in the work. "It's very rare for any medication to [produce] a 31 per cent reduction in mortality, and then even more rare for a non-drug – this is just monitoring people with AI."

Chin Lin at the National Defense Medical Center in Taiwan and his colleagues trained their AI on more than 450,000 electrocardiogram (ECG) tests, which measure the heart's electrical activity, along with the survival data of the ECG subjects. The AI learned to produce a percentile score representing each patient's risk of death, with those in

at least the 95th percentile considered high risk.

The researchers then trialled the AI alert system with 39 physicians at two different hospitals. As nurses uploaded each new patient's ECG tests to a computer server, the AI system would analyse the results and alert physicians if it identified someone as being high risk.

In addition to reducing the risk of death from all causes, the AI system

"This can be implemented in every hospital around the world. It should be the standard of care"

curbed high-risk patient mortality from heart issues by more than 90 per cent (*Nature Medicine*, doi.org/mtdk).

Lin and his colleagues say the AI warnings may help focus attention on the highest risk group. Physicians usually followed up alerts with more tests and treatment. The system is already being used across 14 military hospitals in Taiwan.

"This can be implemented in every hospital around the world," says Topol. "It should be the standard of care when you see this extent of magnitude of benefit." ■
Jeremy Hsu

Animal biology

Wasps have specific brain cells for recognising faces

Sofia Quaglia

WHEN a wasp comes across another, it uses certain brain cells to identify their face. What's more, these neurons seem similar to face-recognition cells in the brains of primates, including humans.



Northern paper wasps can recognise their peers from the markings on their faces

"We have this convergent evolution between these really, really distant species," says Michael Sheehan at Cornell University in New York. He and his colleagues studied northern paper wasps (*Polistes fuscatus*), which each have subtly different colour markings on their faces. The wasps are able to recognise other individual wasps.

Sheehan's team outfitted 18 female wasps with brain probes that recorded which neurons were excited when they were shown a series of more than 2000 images. These included pictures of wasps' faces, wasps with scrambled features, geometrical shapes and random objects like cars.

Out of more than 790 neurons reacting to images, just 35 of them selectively fired when seeing a wasp face (bioRxiv, doi.org/mtdq).

"This study suggests that the social benefits of rapid, accurate face recognition may have independently selected for face-specific cells in both wasps and humans," says Elizabeth Tibbetts at the University of Michigan.

"It's a really bold claim," says Bruno Rossion at the University of Lorraine in France. But just because wasps and primates might have similar networks doesn't mean the networks will work the same, he says. ■

Environment

Plastic pollution treaty would be a 'failure' without tackling emissions

James Dinneen

DELEGATES from nearly every country gathered in Canada last week to hammer out further details of a global treaty to address ballooning plastic pollution. One source of division at the summit, which concluded on 29 April, was how to address the greenhouse gas emissions generated by producing and using plastic, a growing and under-recognised driver of climate change.

"When people think about plastic, they think about what they see," says Alice Zhu at the University of Toronto. But extracting and processing the fossil fuels and other chemicals used to make plastic produces substantial greenhouse gas emissions, as does generating the energy required to make plastic products. Plastic now accounts for about 10 per cent of oil and natural gas demand, with coal also increasingly being used to power plastic production.

Incinerating plastic waste is another source of greenhouse gas emissions. As it degrades,

People taking part in a rally in Ottawa, Canada, against plastic pollution

plastic in the environment can also produce carbon dioxide and methane emissions.

In a study published last month, Nihan Karali at Lawrence Berkeley National Laboratory in California and her colleagues estimated that plastic production in 2019 generated the equivalent of

5%

Share of global emissions from the production of plastic

2.24 gigatonnes of CO₂, or about 5 per cent of global greenhouse gas emissions. That is roughly four times as much as was produced by aviation that year.

Assuming no changes to how plastic is produced, they found these emissions could triple by 2050 with increases in plastic production.

The global plastic treaty under debate could offer a "historic" chance to limit those emissions, the researchers wrote. In 2022, more than 175 countries agreed to join a legally binding treaty that would address plastic pollution across the full life cycle of the material,

with final details to be agreed by the end of this year.

However, a group of petroleum-producing countries, including China and Russia, argued during negotiations that the treaty should only address plastic waste through clean-up and recycling, and not limit production – the main source of greenhouse gas emissions from plastic. A group including the UK and EU have argued the treaty should include provisions to cut production to keep emissions in line with global climate targets.

"There are so many things on the table, and climate is certainly not being discussed too much," says Neil Nathan at the University of California, Santa Barbara, who was at the meeting. Based on modelling he and his colleagues have done, he says a strong treaty – one that limits production and takes steps like mandating that plastic products contain a high proportion of recycled material – could keep emissions at current levels. He says the plastics treaty would be "a failure" if it didn't address production.

Sarah-Jeanne Royer at the University of California, San Diego, says reducing the use of new plastic through recycling or switching to more sustainable materials to make plastic, such as bioplastics or captured CO₂, would also reduce greenhouse gas emissions, even if the treaty didn't address them explicitly.

However, Paul Stegmann at TNO, a research organisation in the Netherlands, cautions that some alternatives to plastic may generate more emissions. "In the end, we need policies that ensure that we do not just shift the problem elsewhere but that reduce the system-wide impact of our society," he says. ■



Infectious diseases

How the US is preparing for a potential bird flu pandemic

Grace Wade



SHUTTERSTOCK/ROMAN MELNYK

AS A bird flu virus continues to spread among dairy cattle in the US, health agencies there are preparing for the possibility of an outbreak in people.

“The risk [of bird flu] remains low at this time, but we continue to be in a strong readiness posture as new data becomes available,” said Vivien Dugan at the US Centers for Disease Control and Prevention (CDC) at a meeting of health officials on 25 April.

A top priority is tracking the virus’s spread. So far, the US Department of Agriculture (USDA) has confirmed H5N1, a subtype of the bird flu virus, in dairy cows on 34 farms across nine states, and in six cats on farms in three of those states.

Genetic sequencing found that only one of the 260 samples from sick dairy cows so far has a mutation indicating H5N1 has adapted to infecting mammals, said Rosemary Sifford at the USDA during the meeting. However, this marker has been seen before in other sick mammals, and didn’t affect the ability of the virus to transmit

between mammals. Plus, the other 10 samples from the same herd where this one was collected didn’t have the same mutation.

“It very much remains an avian virus with no significant changes,” said Sifford.

1 in 5

US cow milk samples have genetic traces of bird flu

The CDC has tested 23 people with close contact to the animals for the virus, according to data shown at the meeting. Only one of them was positive – a dairy worker in Texas whose only symptom was eye redness. To boost testing capabilities, the CDC recently increased funding for genetic sequencing centres in six states, said Dugan.

Another key measure being taken is ensuring the safety of the milk supply in the US. Milk from infected cattle contains high amounts of the virus. While milk from sick animals shouldn’t be entering the milk supply, initial testing from the

Bird flu is affecting dairy cows on some farms in the US

US Food and Drug Administration (FDA) found that 1 in 5 milk samples contain genetic traces of bird flu.

“Importantly, that doesn’t mean the samples contain intact, infective virus,” said Donald Prater at the FDA. The testing method used detects any genetic material, including that of dead virus.

The vast majority of milk sold in the US is pasteurised, a process that kills pathogens with high heat. No study has assessed the impact of pasteurisation on H5N1, but studies of similar influenza viruses suggest it would be effective, said Prater. This is why people should avoid consuming or touching raw milk products.

Two vaccine candidates for H5N1 are also in the works. Initial testing by the CDC indicates both are effective in lab tests against the current strain in cattle, said Dugan.

As part of a pre-established protocol, the US Administration for Strategic Preparedness and Response (ASPR) is stockpiling materials for a bird flu vaccine, said David Boucher at ASPR in the meeting. ASPR and its commercial partners have already filled hundreds of thousands of vaccines for H5N1 that, if needed, can be quickly dispensed for clinical testing or emergency use, he said.

“Based on the CDC’s current risk of the situation, vaccination is not a tool needed at this time. We do want to be ready if that changes, though,” said Boucher. Enough material is stockpiled to churn out an additional 10 million doses, too. ■

Space

Birthplace of red asteroid pinned to specific moon crater

Alex Wilkins

WE MAY have located the birthplace of a strange asteroid that seems to have originated on the moon.

In 2021, astronomers noticed that asteroid 469219 Kamo’oalewa, which orbits the sun on the same trajectory as Earth, looked unusual. The light bouncing off it seemed strangely red, marking it apart from other near-Earth asteroids we know about.

One of the only plausible chemical compositions that could have produced this colour matches that of some lunar rock samples, hinting that the asteroid originally came from the moon. It would have been launched into space as a result of an earlier asteroid smashing into the surface and forming a crater.

Now, Renu Malhotra at the University of Arizona and her colleagues have calculated that the source crater needed to produce such an asteroid would probably be between 10 and 20 kilometres wide and formed in the past several million years. They say that the most likely crater is the Giordano Bruno crater on the moon’s far side (*Nature Astronomy*, doi.org/mtdb).

Malhotra says it is difficult to be more certain until we sample material from the asteroid itself. China plans to return a sample from Kamo’oalewa with its Tianwen-2 mission, scheduled to launch next year. ■

The moon’s Giordano Bruno crater, where asteroid Kamo’oalewa could have originated



NASA/GSFC/ARIZONA STATE UNIVERSITY

Pollution

Car tyre chemicals can get into food

Crops can take up toxic chemicals produced as tyres wear out, but the health risks are unclear

Michael Le Page

TOXIC additives used in tyres can be taken up by plants and end up in our food, according to a study highlighting a source of plastic pollution that is largely unregulated.

“It’s too early to say there’s no risk or high risk from food at the moment, but this might change in the next five years,” says Thilo Hofmann at the University of Vienna in Austria. “Tyre wear particles are a major environmental and health concern, in some cases bigger than other plastic pollution.”

Tyre wear generates about 6 million tonnes of dust per year. It is estimated to make up half of the microplastics entering rivers, lakes and seas, and 80 per cent of the microplastics in air.

The inhalation of tyre dust by people near or on busy roads is the biggest concern, says Hofmann. But additives raise broader issues. Despite some tyres containing hundreds of other compounds in addition to natural and synthetic rubber, these are unregulated, says Hofmann, and tyre makers don’t have to reveal what they add.

Some additives can leach out of tyre dust into water. “Chemicals leaching from plastics, including tyre wear, may be an even greater long-term environmental and human health concern than the physical properties of the particles themselves,” says Hofmann. He points to a 2020 study, which found that a tyre additive was killing coho salmon in rivers, as a reason for concern.

Wear from car tyres produces tiny particles that pollute the air and water

Tyre additives can also blow directly onto fields, or get there after run-off from roads goes into sewage systems and water or solids from that is applied to fields.

To find out if tyre compounds in fields can get into food, Hofmann’s colleague Luzian Hämmerle, also at the University of Vienna, applied four tyre additives with very different chemical structures to lettuces growing in pots in a greenhouse and tested the leaves after three weeks. Significant levels of three of the four compounds were found

in the leaves, with the levels varying according to soil type.

“The message here is very simple. These compounds are taken up under realistic growing conditions,” says Hofmann, who presented the results at a meeting of the European Geosciences Union in Vienna in April.

“The risk to human health is unknown, but we need to act now and restrict chemical plastic pollution,” he says.

“I find the presence of any chemical with toxic properties in foods and environmental systems concerning, and this study again emphasises the importance of only using non-toxic chemicals in tyres,” says Edward Kolodziej at the University of Washington in Seattle, whose team did the coho salmon study.

Other potential solutions could be altering tyres to minimise wear, fitting filters in wheel wells to capture tyre dust and capturing and treating the run-off from busy roads, says Hofmann.

Reducing the total number of cars on public roads would also help, says Hämmerle. ■



DEEPLUE4YOU/GETTY IMAGES

Zoology

Alpaca sex causes injuries that may boost pregnancies

ALPACAS are the only mammals known to science in which males deposit sperm directly into the uterus. This unusual reproductive method inflicts small internal injuries that may help improve the chances of pregnancy.

Patricia Brennan at Mount Holyoke College in Massachusetts and her team examined the reproductive systems of 10 female alpacas that were euthanised within

24 hours of mating. They found bloody abrasions throughout the whole reproductive tract, suggesting that the male alpaca’s penis had thrust its way through the vagina, past the cervix and all the way into the horns of the uterus (*PLoS One*, doi.org/mtdf).

These findings confirm something alpaca researchers have long informally known, says Gregg Adams at the University of Saskatchewan in Canada. This assumption was based in part on the alpaca penis: it is long, stretchy, thin and has a hard tip of cartilage that lets it push through flesh.

Alpacas’ intense intercourse, which can last for up to an hour, may seem unhelpful because it leaves the female’s insides wounded and inflamed. But there may be an evolutionary upside to this.

Adams suggests the wounds’ purpose could be related to alpaca ovulation, which isn’t cyclical like in other mammals but is induced by mating. The inflammation could

“Inflammation could help the female alpaca absorb proteins that trigger ovulation”

help the female alpaca absorb proteins in semen that help trigger ovulation. Prior research from his team had already hinted at this.

A little inflammation in the uterus helps a fertilised egg stick to the uterus walls, says Brennan. This is why doctors often scrape the uterine lining during IVF treatments in humans. Alpaca intercourse may serve a similar purpose.

“We think that alpacas represent an extreme example of the ‘good inflammation hypothesis,’” says Brennan. ■
Sofia Quaglia

Physics

Fusion experiment overcomes two key operating hurdles

Matthew Sparkes

A NUCLEAR fusion reaction has overcome two barriers to operating in a “sweet spot” needed for optimal power production: boosting the plasma density and keeping that denser plasma contained. The milestone is yet another step towards fusion power, although a commercial reactor is still probably years away.

One of the main avenues being explored in efforts to achieve fusion power is using tokamak reactors. These have a doughnut-shaped chamber where plasma hotter than the surface of our sun is contained by vast magnets.

It had been thought that there was a point – known as the Greenwald limit – above which you couldn’t raise the density of the plasma without it escaping the clutches of the magnets, potentially damaging your reactor. But raising density is crucial to increasing output, as experiments have revealed that the output of tokamak reactors rises proportionally with the square of the fuel density.

Now, Siye Ding at General Atomics in San Diego, California, and his colleagues have shown that there is a way to raise the plasma density, and keep it stable, by running the DIII-D National Fusion Facility tokamak reactor for 2.2 seconds with an average density that is 20 per cent above the Greenwald limit. While this barrier has been passed before, with less stability and for shorter durations, this experiment crucially also ran with a metric known as H98(y,2) of above 1 (*Nature*, doi.org/mszm).

H98(y,2) is a complex blend of measurements and values that shows how well the plasma is contained by the magnets,



RSWILCOX (CC BY-SA 4.0)

says Gianluca Sarri at Queen’s University Belfast, UK, with a value of 1 or above signifying that plasma is being successfully held in place.

“You’re now starting to show some sort of stable operation where you can consistently be in the sweet spot,” says Sarri. “This was done in a small machine. If you take these results and extrapolate it to a larger machine... that is expected to put you in a situation where

2.2

Number of seconds the reactor ran with high plasma density

gain and significant power production can be achieved over a significant amount of time.”

The DIII-D experiment relied on a higher density in the core of the doughnut-shaped plasma, to increase output, while allowing it to dip at the edges nearest the containment vessel to drop below the Greenwald limit, therefore avoiding any plasma escape. Deuterium gas was also puffed

Inside the DIII-D tokamak fusion reactor

into the plasma to calm reactions in specific spots.

DIII-D’s plasma chamber has an outside radius of just 1.6 metres, and it isn’t yet known whether the same method would work for ITER, the next-generation tokamak under construction in France, which will have a radius of 6.2 metres and is expected to create plasma as soon as 2025.

“These plasmas are very complicated,” says Sarri. “A small change in conditions leads to a big change in behaviour.”

Ding says the experiment bodes well for fusion power.

“Many reactor designs require simultaneous high confinement and high density. Experimentally, this is the first time it is realised,” he says.

The work is another step towards a practical fusion power plant, but nobody should expect to see a commercial reactor in the next five, or even 10, years, says Sarri. ■

Health

Diet may influence the flu vaccine’s efficacy

Grace Wade

SWITCHING mice to a lower-fat diet before flu vaccination improves their ability to fend off the virus later. This suggests the vaccine may be more effective in people with obesity if they lose weight or eat a different diet beforehand.

Even with immunisation, people with obesity are nearly twice as likely to get the flu than those without it. They are also more vulnerable to severe flu illness. But why obesity seems to blunt vaccine efficacy is unclear, says Stacey Schultz-Cherry at St. Jude Children’s Research Hospital in Tennessee.

To learn more, she and her colleagues took 20 mice that were genetically predisposed to developing obesity and fed them a high-fat diet for four months. They then inoculated the now-obese rodents against the flu. Two weeks later, they put half of the mice on a low-fat diet for a month, which led to weight loss. Afterwards, the animals were infected with a lethal dose of influenza virus. All of the mice died, except for two in the low-fat diet group.

The team then repeated the experiment in a separate group of mice, but this time half went on a low-fat diet a month before vaccination instead of afterwards. When the researchers infected the animals with the same amount of influenza virus, all of those on the low-fat diet survived, whereas all of those on the high-fat diet died (*Nature Microbiology*, doi.org/mszp).

Further research must disentangle whether it was the diet or weight loss that led to these improvements, says Jaswinder Sethi at the University of Southampton in the UK. “I think we have to be very careful about translating these findings to humans too,” says Schultz-Cherry. For instance, a month for mice is equivalent to years for a human, she says. ■

Astrophysics

Giant black holes nurture small ones

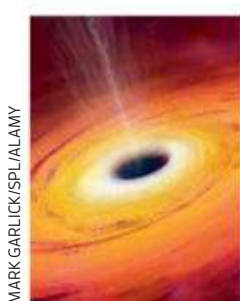
The accretion discs of supermassive black holes may provide a place for mini black holes to grow

Leah Crane

THOUSANDS of relatively small black holes may be circling the supermassive ones that lurk at the centres of galaxies. If so, it would not only help explain how small black holes grow larger, it would also help us understand why supermassive versions appear so bright.

The centres of galaxies are extraordinarily dense, so matter – including relatively small, or stellar-mass, black holes – tends to accumulate there. Some of this matter can fall towards a galaxy's central supermassive black hole, in which case it is known as an active galactic nucleus, or AGN. This creates a glowing, hot ring of plasma around the black hole called an accretion disc. Shuying Zhou at Xiamen University in China and her colleagues have modelled how stellar-mass black holes could end up in these discs and change their appearance.

"Stars and black holes zoom around in a three-dimensional



MARK GARLICK/SPL/ALAMY

Small black holes may explain why the matter swirling around a large black hole is so bright

swarm in the nucleus of the galaxy, around the supermassive black hole, and keep crashing through the thin accretion discs," says Zoltan Haiman at Columbia University in New York, who wasn't involved in the work. The crashes take energy away from the stars and black holes, and eventually they have so little that they are captured by the disc, he says, "like a fly trap".

Zhou and her colleagues found that a supermassive black hole should be surrounded by thousands of these small black holes, and that each of them would develop its own tiny accretion disc, further heating

up the plasma and gas around the AGN (arXiv, doi.org/msx5).

"At first, we thought that the heating due to stellar-mass black holes might play a minor role," says Zhou. "But the stellar-mass black holes can greatly heat up gas in the [AGN] accretion disc." This heating would be particularly noticeable in the outer areas of the disc, which could increase the radius of the disc's glow by more than three times.

If this is happening, it could be a crucial insight into AGNs and how they form. "Currently, we have a lot of holes in knowledge of the physics that create and evolve AGN discs," says Shmuel Gilbaum at the Hebrew University of Jerusalem. "Improving our understanding of AGN discs is crucial for understanding galactic evolution."

It could also explain how black holes grow via collisions. "Black holes are very, very small, so the chances of them randomly meeting and colliding are very

small in this universe with its vast distances," says Imre Bartos at the University of Florida. "The accretion disc acts as a sort of black hole assembly line where smaller black holes meet and collide to form more massive ones."

Although we have observed black holes with masses more than about 50 times that of our sun, how they formed has remained unknown for decades.

"The accretion disc acts as a sort of black hole assembly line where smaller black holes meet and collide"

The effects of the stellar-mass black holes on the accretion discs should be observable, says Rosalba Perna at Stony Brook University in New York. Examining the light from AGNs in different wavelengths may let us see if stellar-mass black holes really are having the predicted effects, she says. ■

Marine biology

Culling starfish conserves coral on Great Barrier Reef

A CULLING programme has protected key areas of the Great Barrier Reef from voracious coral-eating starfish.

Crown-of-thorns starfish are relentless feeders on nearly all species of coral on Australia's Great Barrier Reef. Each starfish can reach 1 metre in diameter and eat 10 square metres of coral reef a year.

The starfish are native to the reef, but it is thought that factors including nutrients pouring into the reef's waters from agriculture have boosted their numbers and worsened the coral destruction.

Between 1985 and 2012, they accounted for 40 per cent of the region's coral loss.

During an eruption of the starfish between 2012 and 2022, the Great Barrier Reef Marine Park Authority ran a culling scheme. Teams of divers injected starfish with a shot of either vinegar or ox bile, which kills them and prevents the release of larvae.

Roger Beeden at the Park Authority and his colleagues found that in areas where timely culling was implemented, the outbreaks were limited and coral cover recovered and increased by up to 44 per cent. Where no culling took place, the loss of coral was severe. The study also confirmed that by preventing outbreaks, larvae didn't



CSIRO

spread to other reefs, meaning further outbreaks were reduced (PLoS One, doi.org/mszh).

The culling has focused on 500 of the marine park's 3000 reefs. The

Crown-of-thorns starfish consume huge amounts of coral

researchers now recommend that it should be expanded to more reefs.

Terry Hughes at James Cook University in Townsville, Australia, doesn't agree that the culling programme is worthwhile. "It's increasingly clear that attempts to protect corals on the Great Barrier Reef by culling crown-of-thorns starfish on a handful of reefs is just a drop in the ocean," he says.

Instead, the priority should be to tackle global warming, which is driving a rise in the frequency and intensity of coral bleaching, says Hughes. ■

James Woodford

Sex differences in brain activity

The brain activity of fetuses and babies seems to become less complicated as they develop and it happens faster in males than females, finds **Moheb Costandi**

THE complexity of signals in the brain seems to decrease as the nervous system develops in fetuses and babies, forcing a rethink of our understanding of the developing brain.

It also decreases faster in males than it does in females, suggesting a fundamental difference in the way the nervous system develops in boys and girls. This could help explain why some conditions, such as autism, disproportionately affect boys.

Joel Frohlich at the University of Tübingen in Germany and his colleagues assessed the brain activity of 43 third-trimester fetuses and 20 babies, aged between 13 and 59 days old. They used a technique called magnetoencephalography (MEG) to measure the magnetic fields produced by the brain's electrical currents in response to sound stimuli. Of the babies, 16 had also had their brain activity recorded in this way when they were fetuses.

The stimuli consisted of various arrangements of beeps. One sequence was made up of four beeps, each lasting 200 milliseconds and separated by 400-millisecond intervals. A "block" of stimuli was defined as 180 sequences, played one after the other with a 1.7-second interval between them. This was played to the fetuses via a "sound balloon" squeezed between the mother's abdomen and the MEG sensors.

Brain training

First, each fetus and baby heard 30 of these blocks of stimuli, as a sort of training. The researchers then recorded their magnetic brain activity on hearing two blocks.

The team calculated several different measures that reflect the complexity of the MEG

signal, using algorithms that determine, for example, how difficult it is to process.

In adults with no known health conditions, higher levels of neural complexity are associated with better performance and faster reaction times in various executive functions, such as planning and decision-making.

"The developing brain eliminates cells and connections that are unnecessary"

Low levels of neural complexity are associated with states in which the capacity for information-processing is reduced, such as while under general anaesthesia and during non-rapid eye movement sleep.

Frohlich and his colleagues therefore hypothesised that MEG signal complexity would rise among the fetuses as gestation progressed and among the babies as they aged.

But they were surprised to

The brain activity of babies seems to get simpler as they get older

find that it actually fell with time, with the decrease occurring significantly faster among the male fetuses and babies than in the female ones (*Nature Mental Health*, doi.org/msw6).

The reason for this decrease is unclear, but one possible explanation is that neural complexity measures different processes as the brain develops.

"The developing brain eliminates cells and connections that are unnecessary, constraining the number of ways in which the brain can respond to a stimulus," says Frohlich.

"As the brain matures, it moves toward ordered patterns of neural connections, which tell it how to respond to stimuli, such as the beeps in our experiment. A more developed brain has fewer ways of responding to that stimulus, and thus lower complexity," he says. "If we were to look at spontaneous activity, we might see something different."

Frohlich suspects that the variation between the sexes might be due to "underlying differences in how the nervous system develops in boys and girls".

The researchers didn't follow the babies beyond the end of the study and it is therefore unclear whether this variation persists as development continues.

A study in 2018 suggested that the complexity of signals obtained from infants using the electroencephalography imaging technique might be useful in predicting autism diagnoses in later life.

Autism is diagnosed four times more often in boys. If it were possible to identify a developmental variable that could detect autism at birth or even earlier, that could allow for potential interventions to start earlier for those infants, which might help with symptoms, says Frohlich.

Sibling connection

To test the technique, researchers could measure neural complexity in fetuses who have an older sibling with autism and are therefore more likely to have the condition themselves, says Frohlich.

"We could follow these children up to their third birthday and see if neural complexity measured in the womb is useful for predicting which children go on to develop autism," he says.

But the idea is controversial. "Autism can only be identified accurately from a thorough clinical assessment by an experienced team of qualified professionals," says Anoushka Pattenden at the National Autistic Society charity in the UK. "Autistic people should receive the support that meets their specific needs and any 'interventions' for autistic people should centre the individual and not make any attempt to reduce autistic characteristics." ■

DMITRI KOTIN/LAMY



Physics

Quantum force used to make tiny device

GOLD traps for capturing and measuring light have been built using strange quantum effects.

Betül Küçüköz at Chalmers University of Technology in Sweden and her colleagues did it using the Casimir effect, a very weak attraction some objects experience when they are held close to one another. This is down to flickers of quantum fields in the gap between them.

The researchers built a light-trapping cavity from gold flakes by placing them in a solution of salty water. The gold moved into place thanks to the electrostatic force caused by electrical charges, and the Casimir effect (*Science Advances*, doi.org/msz6). When two flakes of gold were parallel to one another, light bounced between them, unable to escape.

Karmela Padavic-Callaghan



FIR MANAT/ALAMY

Neuroscience

Rat brain cells let mice smell again

MICE with no sense of smell have gained the ability to sniff out food thanks to rat cells grown inside their brains. This is the first time an organism of one species has experienced the world through the sensory neurons of another.

Kristin Baldwin at Columbia University in New York and her team injected rat stem cells into the embryos of mice that had been genetically modified to lack the neurons for picking up scents. Once the embryos had grown to become adult mice, the researchers found that they had functional neural pathways for sensing smell that included both rat and mouse cells.

These hybrid mice could find hidden mini Oreo cookies easily, unlike mice with the same genetic lack of sense of smell that didn't have rat neurons in their brains (*Cell*, doi.org/msz5). **Tom Leslie**

Botany

Modern rose hybrids lack genetic diversity

COMMERCIAL roses have lost over a quarter of their genetic diversity compared with older varieties, which could leave them vulnerable to disease or climate change.

Roses have been admired and grown since antiquity, when people in Asia and Europe began cultivating varieties from a dozen wild rose species. There were less than 100 varieties before 1800, but by 1900 there were about 8000. Now, there are as many as 35,000.

To reconstruct the genetic history of these plants, Thibault Leroy at the University of Angers, France, and his colleagues sequenced 15 varieties, including ancient European and ancient Asian cultivars, early Asian-European

hybrids and some from a popular group of cultivars known as hybrid tea roses (pictured). By combining the results with genetic studies of 17 other publicly available varieties, the researchers amassed a dataset of the whole genomes of 32 roses. They also looked at data on tens of thousands of genetic markers in more than 200 varieties.

The study found that massively successful commercial varieties, such as hybrid tea roses, are now heavily skewed to an Asian genetic ancestry – only a quarter of their genes are from ancient European varieties (bioRxiv, doi.org/mszq).

In these modern hybrids, more than a quarter of all the genetic diversity seen in ancient cultivars has been eroded. This could be an issue if climate change or disease threatens the industry.

However, Leroy says this risk can be mitigated as long as collectors and botanic gardens conserve their stores of ancient varieties, as these still hold a full suite of genetic diversity. **James Woodford**

Really brief



SVET/ALAMY

Nanorobot swarm removes plastic

In just 2 hours, small metal robots can mop up nanoscopic bits of plastic in water. These spherical devices measure about 200 nanometres across and when exposed to a magnetic field, electrostatic forces make tiny pieces of polystyrene stick to them (*ACS Nanoscience Au*, doi.org/mszs).

Fast ancient shark feasted on shellfish

Analysis of six full-body fossils of a type of shark from the Cretaceous period reveals it swam quickly and ate shell-covered prey. Some members of the *Ptychodus* genus reached about 9.7 metres long, roughly double the size of a great white (*Proceedings of the Royal Society B*, doi.org/msz2).

Japan's lunar lander survives once again

Japan's Smart Lander for Investigating Moon (SLIM) has survived its third lunar night. Such craft typically survive only for one lunar day, which is about two Earth weeks. This is because night on the moon is so cold, getting as low as -133°C, that it ruins spacecraft batteries and electronics.

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A sci-fi thriller sees a professor kidnapped by himself **p29**

Comment

The good old days?

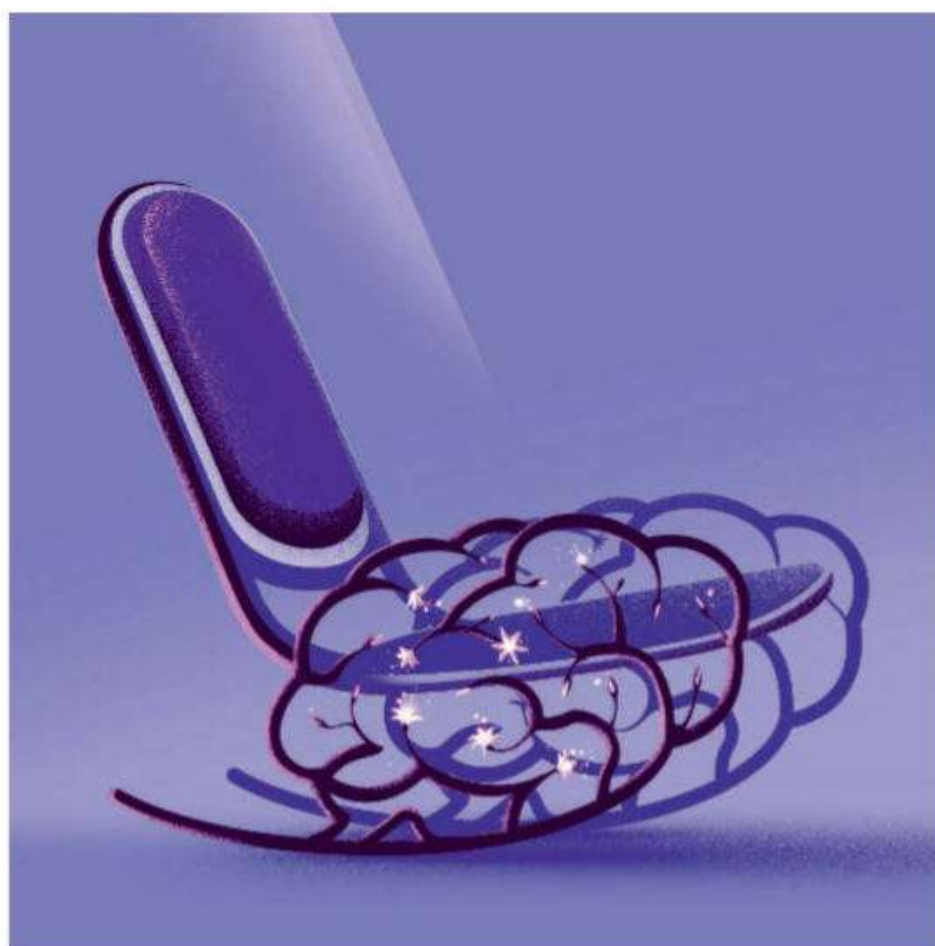
Nostalgia isn't only about a rose-tinted view of the past. It can also be put to use in unexpected places – including work, says **Agnes Arnold-Forster**

FOR hundreds of years, nostalgia wasn't just an emotion, but a potentially deadly disease. Coined by a Swiss physician in 1688, nostalgia struck down servants in 17th-century Germany and killed soldiers in their thousands during the American Civil War. It was a kind of pathological homesickness and while its exact mechanism is unclear, it caused people to slowly waste away. Weak and unable to eat, some starved to death.

These days, we view nostalgia very differently. Now, psychologists and neuroscientists think nostalgia is a predominantly positive, albeit bittersweet, emotion that arises from personally salient, tender, wistful memories of one's past.

But nostalgia isn't just benign. It is also actively therapeutic – a powerful psychological resource that provides people with a variety of benefits. Researchers have found it can boost self-esteem, increase meaning in life, foster a sense of social connectedness and reduce loneliness, stress and anxiety. It can even be used to maintain and improve memory among older adults, enrich psychological health and lessen depression, studies show.

This therapeutic version of nostalgia has been put to use in unexpected places. Organisations of various kinds have tapped into nostalgia's feel-good factor and companies have deployed the emotion in their efforts to improve workforce well-being.



ADRIA VOLTA

The sociologist Yiannis Gabriel was one of the first to coin the term “organisational nostalgia”. He found that nostalgia is a by-product of workplaces where employees have spent many years, especially when the organisation is central to the local community, like coal mines, hospitals and universities. His research subjects told nostalgic stories about former colleagues and reminisced over old office buildings.

Later studies found that organisational nostalgia could be put to use. It strengthened the professional identities of academics, doctors and nurses, for

example, and could be deployed as a personal psychological resource.

Nostalgia at work can look like shared recollections about memorable days in a company's history, or more abstract feelings about the “golden age” of a profession. Psychologists found that this organisational nostalgia helps employees cope with a challenging boss. It could act as an emotional buffer, allowing staff to maintain a feeling of motivation and – helpfully for employers – stop them seeking improved working conditions or altered leadership.

Despite the frustrations of, say,

being denied a voice in important decisions at work, researchers have found that nostalgia provides an “alternative route to social connectedness” that keeps employees cooperative.

One study that interviewed 23 academics in Finland found they yearned for a past when they had more academic freedom. This “idealization of the past” helped the academics clarify their professional values, researchers found, which helped them come to terms with current pressures. And when medical professionals had their autonomy threatened by new ways of working, they could draw on nostalgia to make themselves feel better.

This is all also great news for managers. A major challenge for big organisations is getting people to forgo self-interest and contribute to the collective good. As nostalgia can foster feelings of connectedness, it may make staff more willing to engage in behaviour that benefits their colleagues and the organisation's needs. Other studies have found it even improves staff retention.

While savvy managers can lean on nostalgia to help them get their staff onside, employees can use this research to see where their nostalgia for the workplace could be clouding their judgement. ■



Agnes Arnold-Forster is a historian and author of *Nostalgia: A history of a dangerous emotion*

Field notes from space-time

Turn out the lights Our shift to LEDs is stopping us from seeing the night skies. The way we illuminate the world needs to be part of our green agenda, says **Chanda Prescod-Weinstein**



Chanda Prescod-Weinstein is an associate professor of physics and astronomy, and a core faculty member in women's studies at the University of New Hampshire. Her most recent book is *The Disordered Cosmos: A journey into dark matter, spacetime, and dreams deferred*

Chanda's week

What I'm reading

Chicano Frankenstein by Daniel A. Olivas was so much fun.

What I'm watching

I really think the Coronation Street writers need to stop making Roy suffer so much!

What I'm working on

Thinking about a novel model of dark matter involving a different type of photon than normal.

This column appears monthly. Up next week: Graham Lawton

A STORY I like to tell from my childhood, to help people understand the importance of dark night skies, is about growing up in Los Angeles next to a freeway. I am a child of the smoggy 1980s and 1990s in LA, when the air quality was infamously bad. The city was also incredibly lit-up at night. The smog and light pollution created a situation where we could see almost no celestial features except for the moon and sometimes Venus.

I didn't see a dark night sky until I was a teenager, when I learned for the first time that, given the right conditions, we can see the Milky Way with the naked eye. I had no idea.

Almost two decades later, while I was in Chile on my first and only professional telescope observing run, I stood under a clear southern sky and realised that my ancestors had seen skies like this all the time. They didn't have to travel for 24 hours across thousands of miles. A dark night sky was their norm. This is how they evolved and how they lived every evening. I saw then how much us inner-city kids were denied by the bright lights and air pollution of our beloved hometowns. We were cut off from seeing the cosmos the way our ancestors had.

At the time I had this revelation, a prominent feature of many US cities was that night-time street lights were orange-ish. Many of these were sodium vapour lamps, which emit light at a characteristic frequency for sodium, 589 nanometres. This meant the light was around one wavelength, so was orange, giving cities a kind of fiery halo in the evenings.

The problem with sodium vapour lighting is that it is less energy efficient than newer technologies. Around

the time I was in Chile, there was a big policy push to shift to LED lighting, which uses a lot less energy. It is a great idea. The only problem? The transformation to LED lighting, which was advanced by policy-makers across the US, didn't come with a requirement that the light be filtered to only a single frequency, the way sodium lights work. As a result, a lot of the lighting installed around the country is now white light.

White light is a composition of many different frequencies, and it mimics sunlight. Animals (including humans) have different biological responses to white light

“Amateur astronomers can't easily filter out the light pollution, because it is coming in every frequency”

compared with orange light because we are programmed to interpret it as daylight, so it can disrupt circadian rhythms.

Light pollution can be a problem in any frequency, of course, especially when lighting isn't focused on the place where it is needed: the ground, not the sky. Broad-spectrum LED lighting adds to these challenges when it isn't carefully regulated.

I recently returned to my hometown to participate in the Los Angeles Times Festival of Books and was out late for a few nights due to the festivities. This was my first time going back since taking up amateur astronomy, so of course I looked up, to check the sky.

At around 10pm on my first night, I was shaken by what I saw. The horizon looked like the sun had just set. I knew something was different, but initially couldn't

figure out why it felt strange. Then I realised it was because the horizon was bright white, full of the glow of LED lighting, rather than the orange I grew up with. It also dawned on me with horror that I wouldn't be seeing any stars while I was home. In effect, I relived the nearly-empty night sky of my childhood.

But this time it was different, because I could see in my mind exactly how much was missing. I also knew that it isn't possible for amateur astronomers like my friend Marvin, who tells me he sees fewer stars today than five years ago, to easily filter out the light pollution, because it is now coming in every frequency.

Organisations like DarkSky International have documented the ways in which lighting can function as pollution, with impacts on everything from the very function of ecosystems to our ability to access our cultural night sky heritage. This might seem like a losing battle in metropolises like LA – which, like Randy Newman, I love – but luckily for us, that isn't true. DarkSky International works actively with communities around the world to install responsible lighting that is safely focused on the ground, while also minimising negative impacts on communities. When we talk about being ecologically responsible, the way we illuminate our homes and streets at night has to be part of the conversation.

Want to help? Simple things you can do include installing blackout curtains in your home and making sure any outdoor lighting around your dwelling has shielding that focuses the light towards the ground. Educate yourself too, on the improvements your community can make to lighting – and then spread the knowledge, especially to decision-makers. ■

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Worth the buzz



Photographer Pete Carr
National Museums Liverpool

FEW insects (or even animals) hold quite as much sway on the planet as bees. As pollinators that flock from flower to flower, crop to crop, they keep the world's flora and biodiversity thriving. And yet, thanks to a myriad of deadly factors, such as pesticides, habitat destruction and climate change, thousands of species are teetering on the brink.

A new exhibition all about these vital creatures, *Bees: A story of survival*, provides an immersive window on their world, from the intricate anatomy of a single bee to the structure of entire colonies. In collaboration with artist Wolfgang Buttress, it uses sound, sculpture and light, blending art and technology to show visitors the lives of bees around the world, illuminating just how devastating it would be to lose them.

The main image is of a bee from the genus *Euglossa*, also known as orchid bees. These are a key orchid pollinator in North and South America (although they also flock to rotting fruit, fungi and even faeces). The males, one of which is shown here, use the odours from the chemicals they collect from pollination to court females – the more complex the odour, the greater the attraction.

The column of smaller images shows (top to bottom): a violet carpenter bee (*Xylocopa violacea*), recognisable through its purple-sheened wings and body, and one of the largest bees in Europe; a bee from the genus *Nomioides*, which is one of the smallest types of bee; and an African carpenter bee (*Xylocopa inconstans*).

The exhibition will be at the World Museum in Liverpool, UK, until 5 May 2025. ■

Gege Li

Editor's pick

What to do about the carbon capture crisis?

20 April, p 8

From Geoff Harding, Sydney, Australia

As attempts over the past 20 years have demonstrated, carbon capture and storage is fraught with difficulty and unlikely to make a significant contribution in the future.

A worthwhile alternative strategy in which citizens and various levels of government worldwide can participate is carbon sequestration through tree propagation.

In cities, every backyard and nature strip could be partially or completely forested. Non-productive farmland could be put to far more important use as a carbon sink. Wealthy nations could subsidise reforestation in the Amazon and other damaged rainforests. This is surely a low-cost and effective option and, as is often discussed, greened environments bring considerable health benefits.

From Andrew Taubman,
Sydney, Australia

Carbon capture and storage is a complete waste of time, money and effort. It can't work at the scale necessary to make any meaningful difference in the time available and consumes a lot of energy.

We need to focus on what will make the greatest difference in the least time: a complete cessation of new coal and gas extraction; existing fossil fuel power plants being wound down as soon as possible; German nuclear plants brought back into action, but no new ones built; and all transport powered by electricity or hydrogen. These are the only things that will make any substantial difference.

From John Briggs,
Menith Wood, Worcestershire, UK
Your list of key technologies for carbon capture and storage omits any mention of biochar. This is produced by pyrolysis of agricultural, forestry, garden or

other organic waste materials in limited oxygen/air to produce something akin to charcoal. Most biochar is incorporated into soil, where it can lock carbon away for millennia. A recent report refers to 350,000 metric tons per year of carbon being sequestered this way in 2023. Growth in production has averaged over 90 per cent in the past two years.

Optimise the skin biome rather than destroy it

20 April, p 14

From Chris Eve, Dundee, UK

You report that "post-op infection is often due to skin-dwelling microbes". Surgeons try to prevent these infections by sterilising the skin before cutting into it, but nature abhors a vacuum and when most of the biome is killed you have no control over which organisms multiply to fill the (nearly) empty niche. Maybe it is worth considering painting the skin with a biome that will do no harm – ideally even be helpful – if introduced into a surgical wound.

Scent-loving snakes enjoy making a stink

13 April, p 19

From Bob Ladd, Edinburgh, UK

Many years ago, in eastern Canada, I encountered numerous eastern garter snakes – the species in your report on a study that found they appear to recognise their own scent. Noam Miller, the researcher who found this ability, attributes it to the fact that garter snakes are social creatures, unlike ball pythons, which appear not to know their scent.

However, there is another possible explanation. Garter snakes defend themselves by flailing their tails to smear a

foul-smelling substance, which also gets on their body. Perhaps they are simply more familiar with what they smell like and more likely to notice a small difference.

Obesogenic habits might be very tricky to change

13 April, p 21

From Florence Leroy,
Swindon, Wiltshire, UK

The words "...my peers load their plates with only burgers, fries and pizza" define precisely what is at the heart of the obesity crisis. Pretty much no food is inherently bad. However, the sheer amount of it eaten is. In the UK, US and other places where food is relatively cheap, I have witnessed single servings that could easily have fed four people. Nothing will solve the problem if people aren't willing to change their habits. I am not even sure that education will help, although it can do no harm.

On possible causes of child anxiety

6 April, p 35

From Mike Raynor,
Glossop, Derbyshire, UK

The evidence that anxiety is rising in children is largely unequivocal. You describe several potential causal factors, including social media, interactions at school and socio-economic status.

Another possibility worth mentioning is the use in schools of low-intensity interventions to raise awareness of mental health. These are often given whether or not people present with actual or suspected symptoms.

This is done with the best of intentions, but there is emerging evidence that exposing children without mental health issues to these interventions could cause

harm. It has been suggested that they may trigger some of the conditions they try to prevent by causing some children to over-ruminate on their state of mind. More research is needed to ensure they aren't causing net harm.

Another vote against the many worlds theory

23 March, p 32

From Derek Bolton,
Sydney, Australia

My objections to the many worlds interpretation of quantum theory are that it is necessarily untestable and anyway explains nothing.

To be testable, we would have to be able to detect the influence of one of the other copies of our universe on us for at least some tiny period after separation. Yet, so long as such influence exists, it is, by definition, part of our universe. And it explains nothing because the thing to be explained is quantum collapse. Recasting it as a bifurcation of the universe sheds no light on how it comes to pass.

Why AIs may never be able to think like us

Leader, 13 April

From Andy Smith,
Grimsby, Lincolnshire, UK

You posit that advances in the ability of artificial intelligence to do pure maths may "herald machines that reason and think like humans". While I agree that this will contribute to the ability of AI to reason and gain general level intelligence, it doesn't necessarily mean they will ever think like us.

Human thought can be rational, but it can also be emotional, embodied, spiritual, contradictory and unintelligible. Because of this eclectic mix, people can have experiences, hold values, be hypocritical, act illogically and empathise. Unless these are emergent phenomena of the complexity required to create intelligence, it is likely that these attributes will prove challenging to replicate artificially. ■

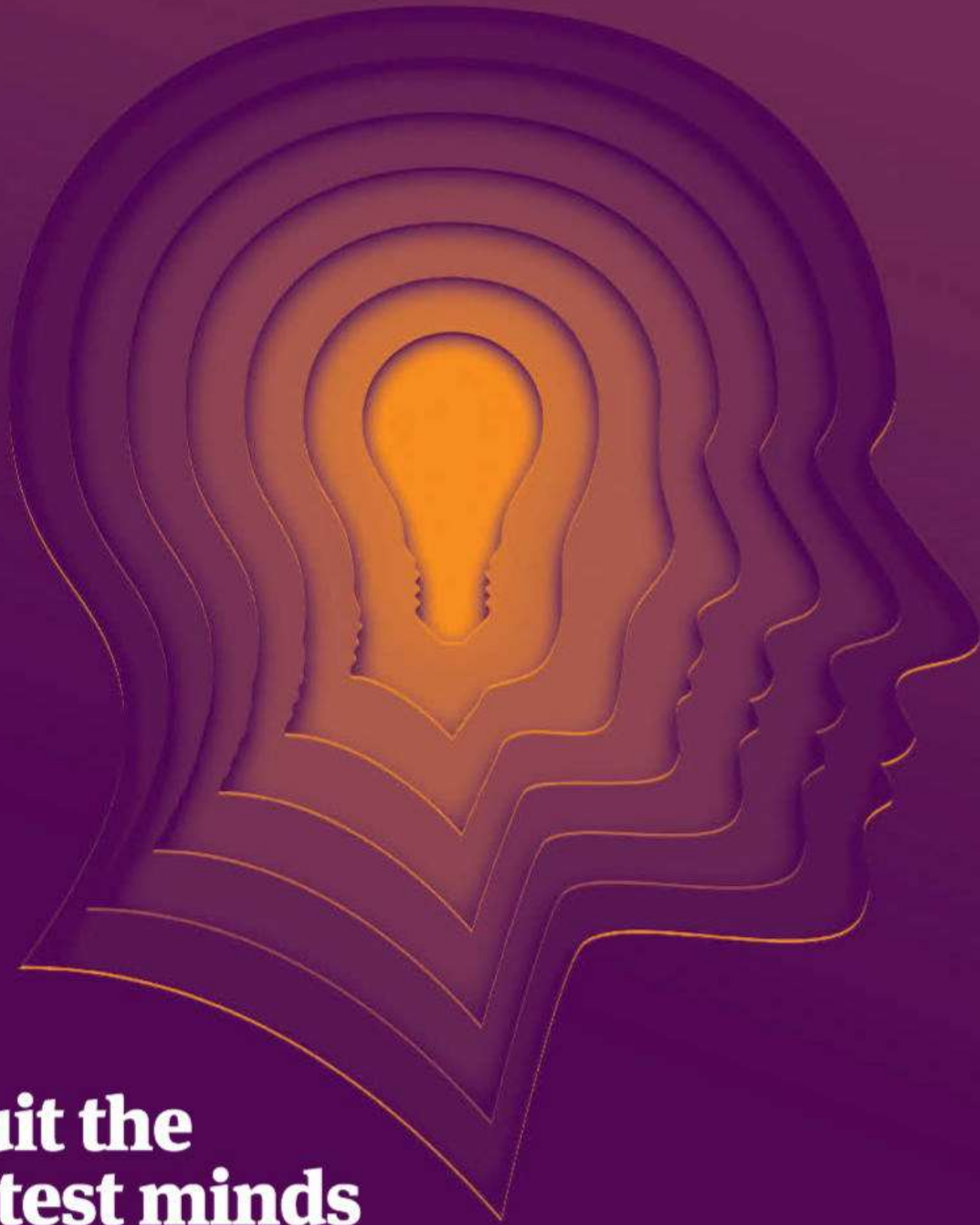


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A fix for our weighty problem?

The use of Ozempic as a weight-loss drug signals a new approach to tackling obesity. **Clare Wilson** explores a riveting, if flawed, first-person account



Book

Magic Pill

Johann Hari

Bloomsbury Publishing (UK)

Crown Publishing (US)

AS BOTH a cultural phenomenon and one of the most successful new drugs of the 21st century, it was inevitable we would soon see popular science books written about the weight-loss drug Wegovy (also sold as Ozempic) and other similar medicines. Among the first is *Magic Pill: The extraordinary benefits and disturbing risks of the new weight-loss drugs* by Johann Hari.

For two years, Hari has been fortunate enough, journalistically speaking, to be taking one of these medicines of the moment, which work by mimicking a gut hormone called GLP-1, normally released after eating to make us feel full. Hari tells their story through the irresistible literary device of being his own case study.

The Ozempic phenomenon falls squarely in my beat as health reporter at *New Scientist*, but I began reading *Magic Pill* with trepidation. Hari is infamous in British media circles for resigning in disgrace from *The Independent* newspaper in 2012 after being caught plagiarising and maliciously editing Wikipedia pages about his critics.

After apologising and saying that he would take journalism training, Hari has reinvented himself as a non-fiction writer specialising in medical controversies.

Despite my reservations, I couldn't put *Magic Pill* down. Hari bares his soul about his personal battles with weight and Ozempic's unpleasant side effects. He also explores why obesity rates have



EGGY SAYOGA/ALAMY

been climbing in almost every country in the world, and skilfully recounts how these drugs were discovered and what we are still learning about how they work.

The chapter on Japan's approach to preventing obesity is fascinating. It is clear that Western countries could learn from some initiatives, such as

“Johann Hari bares his soul about his personal battles with weight and Ozempic's unpleasant side effects”

the focus on healthy school meals. But others are unlikely to be widely transferable, such as the measures by some companies to keep their workers trim – including by tracking their weight, exercise and meals.

Cynics might complain that, in his previous books, Hari was keener to “pill shame” when it came to medicines for depression and ADHD than with a drug that he personally benefits from. That would be unfair, as Hari bends over backwards to explore

potential problems with the GLP-1 mimics. These range from the obvious – such as the risk that they will be abused by people with eating disorders – to the speculative, such as that people may be harmed if they can no longer use overeating as an emotional crutch, something Hari says he does.

More concerning is when he seems to exaggerate the science, perhaps due to misunderstandings, misplaced faith in some of his celebrity scientist interviewees or the need to weave a compelling narrative.

For instance, Hari seems to misinterpret the conclusions we should draw from an important but brief trial comparing processed foods with whole foods, when he implies that junk food makes people eat 500 more calories a day than they need, in perpetuity. Clearly that couldn't possibly be correct.

Another issue for me is that, although we don't know why obesity rates are rising, Hari regurgitates dogmatic claims from whichever scientist he has just interviewed, whether they

Drugs, such as Ozempic, may help turn the rising tide of global obesity

blame blood sugar spikes, artificial sweeteners or damage to the gut microbiome. These factors are certainly suspects for contributing to rising obesity, but as yet there is no hard evidence.

For example, Hari repeats one scientist's unlikely claim that your gut bacteria are “just as important as your brain”. This must come as a surprise to people happily walking around after the surgical removal of their entire colon, the home to nearly all our gut bacteria.

These caveats aside, I would still recommend this book for anyone taking, or considering taking, any of these weight-loss drugs or anyone who just wants to know about their wider impact.

Unlike much of the commentary on this topic, which focuses on short-term problems, such as the drugs' high cost, Hari gets that, in time, they could have as big an impact as the arrival of antidepressants, speculating how they may reshape global health.

I found it a fascinating read. ■



Sophie Bushwick
Editor
New York

Birth control helps give half the world's population a life outside the home. But the women who made it possible in the 1950s



were never told they were subjects in the pill's first large human trial.

Las Borriqueñas by Nelson Diaz-Marciano, on at the Ensemble Studio Theatre, New York, tells the story of five Puerto Rican women in the trial. They gossip and dream, but are restricted by limited family planning options: undependable partners, potentially deadly abortion or sterilisation.

The pill is a game-changer, but has severe side effects (the trial used much higher hormone levels than now). Their reports dismissed, the women realise they are guinea pigs. The play can get bogged down in exposition, but it makes clear the need for the pill, while asking who was really empowered by this medication.

Fallout (Amazon Prime Video) is gorier, sillier, and its "science" mostly fiction. I love the mutant monsters, corporate conspiracies, and parody of nuclear-age optimism, complete with jello cake.

Life in the multiverse

A sci-fi thriller sees physics professor Jason kidnapped by a version of himself, out to take over his life, finds **Josh Bell**



TV

Dark Matter

Blake Crouch

Apple TV+ from 8 May

EVERYONE knows about the multiverse now. Thanks to the Marvel Cinematic Universe and popular movies like *Everything Everywhere All At Once*, the idea of infinite parallel worlds adjacent to ours is somewhat commonplace. So it isn't a mind-blowing reveal in the new TV show *Dark Matter* when protagonist Jason Dessen (Joel Edgerton) finds that he has been transported into an alternate dimension where another version of himself lived a different life.

What is potentially exciting about this Apple TV+ series is what creator Blake Crouch does with the multiverse concept, and that most of the show's storytelling is gripping and fast-paced. Crouch adapted *Dark Matter* from his own 2016 novel and wrote or co-wrote six of the nine episodes. The show has a more cohesive tone than the last TV

show adapted from a Crouch novel, 2015's mostly ridiculous *Wayward Pines*. But at times, it could use some of that show's outlandish spirit, especially in a setting where literally anything is possible.

Jason, as introduced in the first episode, has a pretty mundane life: he is a physics professor at a mid-level college in Chicago, husband to art gallery manager Daniela (Jennifer Connelly) and father to teenage son Charlie (Oakes Fegley). When he finds out that his old university friend Ryan (Jimmi Simpson) has won a prestigious physics prize, he experiences a twinge of jealousy about what could have been, and agrees to consider a corporate job offer from Ryan.

He is wholly unprepared to be thrust into an entirely new life, though, which is what happens when he is assaulted and kidnapped by another version of himself. This other Jason – referred to in the credits as J2 – has developed a device that can place a human being in superposition, a state of quantum uncertainty that J2 calls "five-dimensional probability space". In practical terms, it is a huge black box that extends itself into an infinite corridor with infinite doors that a user can open, each leading

to a different alternate world.

Dumped without explanation into J2's world, Jason is desperate to return home to Daniela and Charlie. Meanwhile, J2 attempts to take over Jason's life, to capture the familial fulfilment he sacrificed to focus on his scientific research. *Dark Matter* really gets going once Jason escapes from the clutches of J2's nefarious boss Leighton (Dayo Okeniyi) and enters the multiverse, aided by J2's psychologist colleague and past love, Amanda (Alice Braga).

On their quest to return to Jason's home reality, he and Amanda visit plenty of different worlds, and Crouch offers up some creative variations while sticking to a mostly sombre, grounded tone. The closest that *Dark Matter* gets to the kind of endearingly cheesy alt-universe adventures of a show like cult classic *Sliders* is when Jason and Amanda end up in a world overrun by giant killer bees, but even then, there is only a brief glimpse before they move on.

Dark Matter could have probably used more giant bees and less domestic drama, although Edgerton has strong chemistry with both Connelly and Braga. He is shakier when called upon to effectively differentiate the multiple versions of Jason, but the show helpfully provides sound-effect cues whenever switching universes.

Crouch elegantly ties the mechanism for travelling between worlds to the characters' emotional states, and *Dark Matter* is best when it balances big sci-fi ideas with meaningful personal stakes.

The finale teases even more possibilities beyond the bounds of Crouch's novel, offering the hope of an alternate universe where the show is just a bit goofier – and thus a bit more entertaining. ■

Josh Bell is a writer and critic based in Las Vegas, Nevada



SANDY MORRIS/APPLE TV+

VALERIE TERRANOVA PHOTOGRAPHY

Why we love woo-woo

From ghosts to reincarnation, it takes a well-rounded sceptic to find a rational, humane course through such claims, finds **Wendy Grossman**



Book

The Science of Weird Shit

Chris French
MIT Press

DURING a TV show in the early 1990s, a man describes waking up in the night with a weight pressing on his chest. He could neither move nor breathe. He says this is the result of a visiting ghost. Later that week, on another TV show, a different man tells a similar story of waking up in the night with a weight on his chest. He, too, could neither move nor breathe. For him, the cause was a visiting alien.

I heard both stories live, having been invited onto the shows as the then editor of *The Skeptic* magazine. It seemed obvious that both men were experiencing something real and physical, and that, for both, the interpretation lay in their belief systems. Familiar with the work of experts like Chris French, a researcher at what is now Goldsmiths, University of London, I knew the name of what had really happened to them: sleep paralysis.

Some years later, French has written a nuanced book about this phenomenon and the many others that attract non-scientific explanations. In *The Science of Weird Shit: Why our minds conjure the paranormal*, he shares historical accounts and scientific studies showing that the feeling of a presence can be very strong during sleep paralysis, often an unnerving (if relatively common) experience.

Small wonder, then, that such events produce paranormal interpretations. In reality, says French, sleep paralysis “can be thought of as glitches in the normal sleep cycle during which, to put it simply, the mind wakes up but the body does not”.



PETER LENK/ALAMY

A cognitive bias called pareidolia leads people to see a face in this tree

French now runs the Anomalistic Psychology Research Unit at Goldsmiths (“anomalistic” is the polite version of “weird shit”). When he set out, few considered the field worthy of study. French originally believed in the paranormal, became what he calls a “dogmatic” sceptic, then shifted slowly to understanding that “it’s complicated”.

Here, in a book that reads like a non-fiction thriller, his first job is to define the paranormal, opting to follow the Cambridge Dictionary entry: “impossible to explain by known natural forces or by science”. It isn’t perfect, he says – for example, consciousness fits that description, though few call that paranormal.

But the definition is good enough, because it takes in the three main general areas parapsychologists think about: extrasensory perception, psychokinesis and life after death. These areas lead French into alien

abductions, false memories, reincarnation, precognitive dreams, coincidences and more.

He isn’t the first to write a general book on the paranormal. What makes his different is its mix of academic knowledge and practical application. For example, this approach offers opportunities to explore the cognitive biases that

“French believed in the paranormal, became a ‘dogmatic’ sceptic, then shifted slowly to ‘it’s complicated’”

can negatively affect our decisions and behaviour. Take pareidolia, where we perceive meaningful images from random patterns – such as a face in a tree or in stains.

Then there is suggestibility, where we are primed to accept false memories as real. French has run experiments showing how memory works, as opposed to how we think it works. We process a mere fraction of the sensory information available (known as bottom-up processing) and have

to fill in gaps from what we already know (top-down processing). Constant interaction between the processes helps create a good-enough model of our world. But there is also the potential for error: illusory perceptions creep in if the input is ambiguous or degraded. This, he says, is how we end up seeing things that aren’t there.

In one experiment, he found most people don’t remember how “four” appears on clock faces that use Roman numerals. Participants opted for IV, as it looks elsewhere, when in fact it is represented on most timepieces as IIII.

French has been a frequent guest on TV shows to explain phenomena, run tests on psychics or, in one of his nervier exploits, perform a cold reading as a “psychic”. This relies on making vague, general statements and on observing the subject’s reactions, often appearing to know details they haven’t disclosed. The sitter gave his reading a glowing review.

Another time, he joined a TV crew documenting the belief in reincarnation common among the Druze people, a religious sect in Lebanon. While they failed to turn up evidence to support the belief, French concluded the Druze may benefit from it because families help children claiming to be the reincarnation of one of their own.

In *The Science of Weird Shit*, French’s goal isn’t to tell people they are wrong, but to set their experiences in the context of psychology. He understands that it is all very much a matter of interpretation. If they wanted, he tells students, he could present a course taking the believer’s side and convince them of the paranormal. But he doesn’t. ■

Wendy Grossman is a writer based in London

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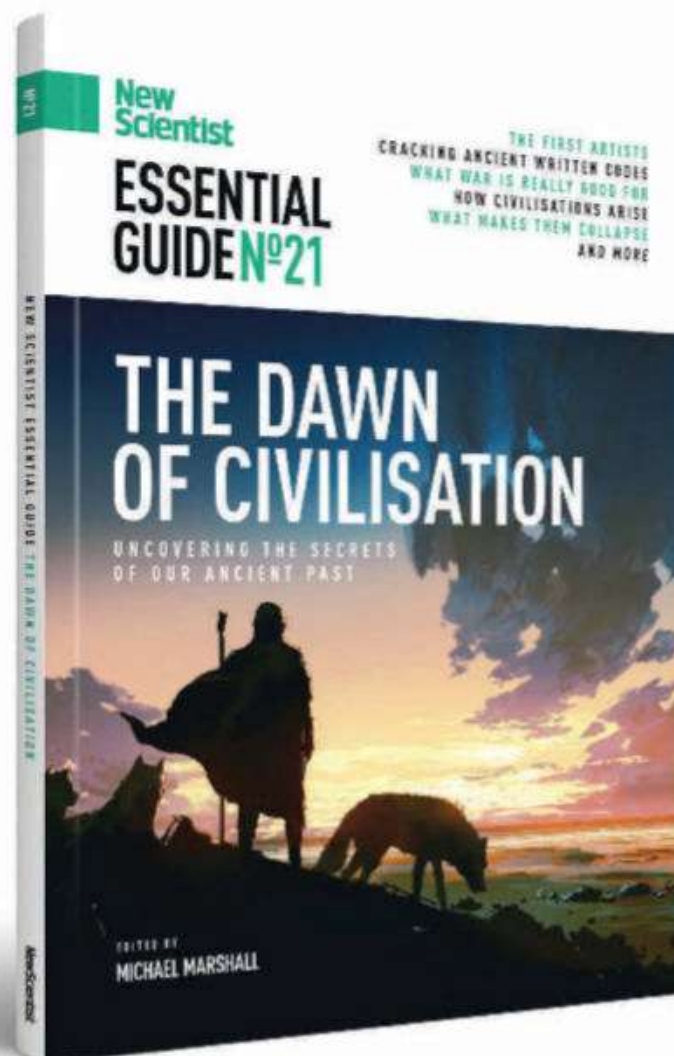
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MY YOUNGEST son has been allergic to peanuts and sesame since he was a toddler. Though he has never had a life-threatening reaction, the risk of one hangs over him constantly. He can't eat out in most restaurants or travel to many parts of the world. Grocery shopping is an ordeal. He has his own place now, and I live in constant anxiety. We always hoped he would grow out of his allergies. At 21, he almost certainly won't.

He is in an increasingly crowded boat. For reasons that aren't well understood, food allergies have grown explosively in the 21st century. Peanuts are a common trigger, as are wheat, cow's milk, egg, soya, other nuts, fish and shellfish. Beyond the "big eight" lies a long tail of allergies to other foods, including many fruits, vegetables and seeds. Some people are allergic to beer, others to cannabis. If humans consume it, chances are somebody, somewhere, is allergic to it.

This rise has translated into an increased burden on healthcare and a reduced quality of life for many, as they strive to avoid a potentially fatal reaction. Until recently, there was only one way to avert this outcome: don't eat the trigger food. That is easier said than done, however, with unexpected ingredients incorporated into processed foods and labelling often ambiguous or inaccurate.

But now, finally, there is hope on the horizon, with the arrival of several new therapies that can help people avoid an allergic reaction, not just to food, but other kinds of triggers too. "An exciting era is near," says Idil Ezhuthachan

at Emory University in Atlanta, Georgia.

Getting a firm handle on the prevalence of food allergies is quite difficult, as there are various ways of measuring it. But most studies have found a recent increase, at least in adults. Food safety surveys carried out by the US Food and Drug Administration (FDA) found that the number of adults self-reporting a food allergy increased from 9.1 per cent in 2001 to 13 per cent in 2010. In 2019, a different research group found that the figure was 19 per cent. The prevalence in children has remained at about 8 per cent for the past decade or so.

At the same time, hospital admissions for severe allergic reactions have risen dramatically. In the US, the number per 100,000 people increased from 153 in 2004 to 218 in 2016. The equivalent figure in the UK grew by more than 179 per cent from 1998 until 2018.

The rise in adult cases has belatedly captured the attention of epidemiologists who were previously focused on childhood allergies, says Christopher Warren at Northwestern University in Illinois. It is in part due to children with allergies growing up, but not growing out of the condition as frequently as expected – only about 20 per cent of children outgrow a peanut allergy. But it is also due to adult-onset allergies, which "seem increasingly common", according to Warren.

First and foremost among these is pollen food syndrome. In this case, the primary allergy is to some variety of airborne pollen, which triggers hay fever as a result of the immune system mistakenly recognising

The end of allergies?

Have we finally found a way to stop people having dangerous allergic reactions, asks **Graham Lawton**





proteins (or “allergens”) within the pollen as dangerous. People with this allergy also tend to have a reaction to foods containing closely related allergens. The main one in birch pollen, for example, is almost identical to those found in apples and hazelnuts. An allergy to mugwort pollen can also make people sensitive to wheat, peach, walnuts, soy and latex.

Seafood is also a common trigger in adults: in the US, about 60 per cent of shellfish allergies and 40 per cent of finfish allergies arise in adulthood, according to Jay Lieberman at the University of Tennessee Health Science Center in Memphis. We don’t know why these foods are tolerated for years then suddenly trigger allergies, he says.

Under your skin

Childhood food allergies are also a bit of a head-scratcher. There is clearly a genetic component that can put people at higher risk of developing one, but what makes some people’s bodies react to an otherwise innocuous environmental trigger is still unknown (see “How to prevent your child from developing food allergies”, page 34). The hygiene hypothesis, which posits that living in an excessively sterile environment in early childhood leads to poor immune tolerance later in life, lacks convincing evidence, according to Gideon Lack at King’s College London.

The most promising explanation for child-onset allergies is cutaneous exposure, where food allergens penetrate broken skin ➤

“Having a drug that
can offer another
level of protection
is priceless”

How to prevent your child from developing food allergies

Most people with severe food allergies have a genetic susceptibility, according to Idil Ezhuthachan at Emory University in Atlanta, Georgia. If allergies run in your family, then your children are at higher risk of developing one. But biology isn't destiny and there are things that parents can do to prevent an allergy arising.

Number one is early exposure. When my late wife was carrying and breastfeeding our peanut-allergic son (see main story), the advice in the UK was for her to avoid eating peanuts, which she did. We were also advised to delay introducing peanuts into his diet during weaning. But research subsequently showed that these strategies have no benefit and the advice was withdrawn in 2008.

Indeed, such measures may be counterproductive. Numerous studies have shown that early introduction of multiple typical allergens, such as peanut and egg, reduces the risk of any allergy, and infant weaning guidelines in the US now encourage the early addition of common allergy triggering foods. In early life, the gastrointestinal tract is primed to promote tolerance to allergens and will do so if exposed to them early.

Another is to keep an eye out for

the skin condition eczema, which often precedes the development of food allergies. Eczema causes broken skin, allowing potential food allergens to access the immune system deep under the skin, which is less tolerant of them. Early introduction of common allergens can help prevent this, and so can treatments for eczema. "I get excited whenever I see a baby with eczema in my clinic because I feel like 'oh, now I can make a difference in your life, let's fix your eczema so that we prevent food allergy,'" says Ezhuthachan.

Introducing eggs into the diet at an early age can reduce the risk of an allergy



MARTIN PARR/MAGNUM PHOTOS

and trigger an immune response, which is then encoded into an immune memory, says Ezhuthachan. This fits with what is known as the "allergic march", where children who initially develop eczema are much more likely to subsequently develop food allergies, asthma and hay fever. The broken skin that characterises eczema may be the route by which food allergens first encounter the immune system. However, "the processes governing this loss of tolerance are incompletely understood", says Jyothi Tirumalasetty at Stanford University in California.

On the other hand, the mechanics of allergic reactions are now well-known, which is partly the reason for the recent surge of new treatments. A reaction starts when the immune system misidentifies something innocuous as a threat and goes into blitz-

defence mode. In a classic reaction, a type of white blood cell called a helper T-cell recognises an allergen and sounds the alarm, stimulating B-cells to release an antibody called immunoglobulin E (IgE). This binds to target cells, triggering a flood of inflammatory molecules, including histamines. Cue the classic allergic reaction: swelling, itching, streaming eyes and nose, hives and, in the case of food, vomiting and diarrhoea.

Threat to life

Histamines also cause blood vessels to dilate, leading to a rapid drop in blood pressure. In severe cases, these immune responses can be fatal. Swelling of the airways and tongue make it difficult to breathe, while catastrophically low blood pressure can progress to a state called anaphylactic shock, where not enough blood reaches tissues. This can lead to unconsciousness and cardiac arrest.

The only treatment for severe allergic reactions at present is epinephrine, also known as adrenaline, which rapidly dilates the airways, constricts blood vessels and speeds up the heart. That is why people with life-threatening allergies often carry injectable doses of epinephrine in an EpiPen or similar. Swift action can make the difference between life and death.

Still, around half of people with a severe food allergy have had at least one severe reaction and roughly a third have been hospitalised. In the US, between 50 and 100 people die from anaphylactic shock after ingesting peanuts every year.

Anaphylaxis can escalate, with subsequent attacks worse than the previous one. And about 20 per cent of people experience a "biphasic" shock, with a second wave of anaphylactic symptoms hours or even days after the first. "People with severe food allergy, especially those who are allergic to multiple foods, have a substantial need for effective and safe treatments," says Gary Wong at the Chinese University of Hong Kong.

Such treatments finally appear to be on the horizon after years of promise. Back in the 1980s, scientists at biotech company Tanox in Houston, Texas, hit on a potentially life-saving concept. If severe allergies were triggered by IgE, why not target that? They developed a drug called TNX-901 that binds tightly to IgE and stops it from latching on to cells that would otherwise release inflammatory molecules like histamines. The idea was to give regular

"A third of people with severe food allergies end up in hospital"



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injections of TNX-901 to people with severe allergies to protect them from an IgE storm if they accidentally ate their trigger food.

In a subsequent clinical trial published in 2003, involving 84 volunteers aged 12 to 60 who had a peanut allergy, Tanox showed that the concept worked: four injections of TNX-901 over 12 weeks “significantly and substantially” increased participants’ tolerance threshold from an average of about half a peanut to almost nine peanuts. That, according to the researchers, was sufficient headroom to protect against most unintended ingestions.

Unfortunately, this promising tool didn’t get off the ground. The trial was halted due to a legal dispute between Tanox and its industry partners, Novartis and Genentech, over who owned the right to develop the drug. TNX-901 never saw the light of day.

In the meantime, however, a different strategy called oral immunotherapy (OIT) was being tested. This involves feeding people with food allergies tiny but escalating doses of their trigger allergen. The idea is that doses initially too small to provoke a reaction will gradually retrain the immune system to tolerate the offending substance.

This technique isn’t actually new – the first recorded case of OIT was published in 1908, concerning a 13-year-old boy with a severe egg allergy. His doctor, a practitioner at London’s Harley Street called Alfred Schofield, hypothesised that egg proteins were causing the boy’s blood vessels to become leaky, so he started feeding him tiny amounts of egg to



DAVID MCCLAIN/CAVAN IMAGES/ALAMY

Why people suddenly react to specific foods isn’t well understood

make his system tolerate the foodstuff. He initially administered a ten-thousandth of an egg per day and built up gradually to a sixth of an egg. Within months, the boy was able to eat whole eggs without a reaction.

Despite the positive result, the approach was considered too risky and OIT fell by the wayside. It wasn’t until the 1990s that it was revisited, and numerous studies have since successfully used it in people, mainly children, for peanuts, cow’s milk, eggs and fish. One study found that OIT could induce “sustained unresponsiveness” to eggs, meaning that people could eat normal quantities of this food with no reaction. In 2017, the European Academy of Allergy and Clinical Immunology recommended OIT for children with allergies to cow’s milk, eggs or peanuts. In 2020, the FDA and the European Medicines Agency approved an oral peanut formulation for 4 to 17-year-olds called Palforzia, developed by Aimmune Therapeutics of Bridgewater, New Jersey.

But OIT is far from perfect. One problem, says Sharon Chinthrajah at Stanford University, is that it is laborious. It can only desensitise people to one allergen at a time, but she says at least 43 per cent of children with a food allergy in the US are allergic to more than one food. It is also still risky, she says: allergic reactions, even anaphylaxis, during the process are common.

Attacking asthma

Fortunately, the IgE-blocking concept was also eventually revived. Before teaming up with Tanox, Genentech and Novartis had developed their own anti-IgE monoclonal antibody called omalizumab, trade name Xolair. They initially tested it against asthma triggered by airborne allergens and won regulatory approval for that use in 2003.

Next in the crosshairs were peanuts. Things got off to a rocky start: the first clinical trial of omalizumab for peanut allergy had to stop recruiting when two of the volunteers had anaphylactic shocks during tests to measure their baseline tolerance to this food. But the nine volunteers who got the drug showed an 80-fold increase in their tolerance.

Since then, more trials of the drug have been carried out on peanut allergy with good results. Some doctors started giving omalizumab to people with food allergies even though it didn’t have regulatory clearance, says Wong.

The latest results were unveiled in



PAT CANOVA/ALAMY



Reactions to pollen often appear along with those to food

SOREN NIELSEN/IMAGE SOURCE LIMITED/ALAMY

February. A team led by Chinthrajah and Robert Wood at Johns Hopkins University in Maryland gave 177 children and adolescents who were highly allergic to peanuts a course of omalizumab injections or a placebo, then tested whether their sensitivity to peanuts decreased. About two-thirds of the volunteers who received the drug experienced at least a six-fold increase in their tolerance, from less than half a peanut to around 2.5 peanuts. That is enough to prevent anaphylaxis after most accidental ingestions, the researchers say.

“Even in the most careful families, mistakes happen,” says Chinthrajah. “So to have a drug that offers another level of protection I think is really priceless.”

And it didn’t just desensitise the participants to peanuts. To qualify for the trial, the volunteers also had to be allergic to at least two other trigger foods, out of cashews, eggs, hazelnuts, milk, walnuts and wheat. Participants who got the drug experienced a similar increase in tolerance to those other foods. On the back of that data, on 16 February, the FDA approved omalizumab as the first drug for peanut allergy, ending a decades-long wait. “It’s really exciting to have something approved,” says Ezhuthachan, who wasn’t involved in the trial. “I think it’s going to have a really good role.”

But it isn’t the final answer, she says. The drug is expensive and its effects wear off, necessitating injections every two to four weeks.

The lack of success in a third of volunteers is also an issue, says Chinthrajah. “It is critical

“A new class of drugs could halt dangerous allergic reactions after they have begun”

for us to understand the biology behind responders and non-responders, but that will enable us to fine-tune our therapeutics and push the needle beyond two-thirds. There’s a lot more to be done, but I do think we should take a moment and celebrate this great victory.”

These results are just the start. Two other trials of omalizumab are also ongoing, one combining it with OIT. The hope is that giving the drug during the OIT’s escalation phase will make the process safer, and that it can later be withdrawn, whereupon tolerance can be maintained by OIT alone.

There are also more potent IgE blockers in the pipeline. One, ligelizumab, is being tested against peanut allergy. A late-stage trial was recently terminated by manufacturer Novartis for undisclosed reasons, but the company says it will start another trial later this year. Yet

another IgE blocker, UB-221 from Taiwanese company United BioPharma, is being tested against eczema and, according to Chinthrajah, has “great potential in food allergy”.

A slightly different approach is to disrupt IgE as well as block it. Once IgE has bound to its target cells, initiating the release of histamine, blockers are largely powerless to intervene. But a new class of drugs called disruptive IgE inhibitors not only stop IgE from binding, but also lever it off target cells once it has bound. They aren’t yet in clinical trials, but show promise as a rapid rescue remedy for anaphylaxis, according to Chinthrajah. People who start to have an allergic reaction could use them like an EpiPen to halt the potentially deadly cascade.

Multiple existing drugs are also being eyed with a view to repurposing them for food allergy, and there are several vaccines in development, though these are at a very early stage. As a result, after decades of having little to offer people with food allergies, there is suddenly a sense of a new dawn. “It’s a game changer,” says Chinthrajah.

Ultimately, the hope is to take the sting out of all severe allergies. Most anaphylactic shocks are caused by food, but they can also be triggered by latex, insect stings and animal venoms. There is also a condition called idiopathic anaphylaxis where the shock comes on with no apparent cause. IgE blockers could, in principle, deal with all of these.

Then there is allergic asthma, which is triggered by airborne allergens such as pollen and pet dander. It accounts for the majority of asthma attacks, which kill 455,000 people a year. Omalizumab is already approved for this condition, but better IgE blockers could transform that illness too.

My son also has asthma, which is well-controlled but occasionally flares up. I know that a new drug to eliminate this risk, and also remove the threat of food-related anaphylaxis, would improve his – and my – life immeasurably, and those of millions of people in a similar position. Is that in our future? Yes, says Ezhuthachan. “I think that’s eventually where we’re going to get to.” ■

You should consult your doctor before starting medical treatment



Graham Lawton is a staff writer at *New Scientist*

Earning its stripes

An extraordinary formation that has long attracted geologists and fossil hunters could soon establish Kyrgyzstan as a tourist hotspot, finds **Diana Kruzman**

AROUND 235 million years ago, in what is now central Asia, a small reptile fell into a freshwater lake and settled in the soft mud at the bottom. The creature – named *Longisquama*, meaning “long scales”, after the strange, feather-like protrusions on its back – probably lived in a nearby forest with a host of other curious animals, including a flying reptile known as *Sharovipteryx* and *Gigatitan*, a giant mantis-like insect.

As the *Longisquama*'s body slowly decayed and gradually turned to stone, continents drifted and the landscape

above changed, with the lake drying up and reforming numerous times. Then, in the 1960s, Soviet palaeontologist Aleksandr Sharov found the fossilised reptile and shone a scientific spotlight on this little-known corner of the USSR.

Today, the region is in southern Kyrgyzstan, a dusty landscape of colourful rock outcrops and dry riverbeds framed by the snow-capped peaks of the Turkestan range. These rocks, remnants of the layers of mud and silt deposited on the lake bed on which *Longisquama* came to rest, are called the Madygen formation,

after a nearby village. Palaeontologists recognise it as one of the world's richest Triassic fossil beds and a lagerstätte – a site with exquisitely preserved specimens – but few other people have heard of Madygen.

That looks set to change. If all goes to plan, this year the region will become a Global Geopark, the first in central Asia. As well as showcasing this natural wonder, the designation will help prevent it being despoiled by mining. It will also give an economic and political boost to Kyrgyzstan, a nation that has faced many challenges since it achieved independence ➤



from the USSR over three decades ago.

With undulating waves of red, yellow and white rocks that stand out like a scar in the desert, the Madygen formation is visually striking. But it is just part of a proposed park, also called Madygen, which will cover 50 hectares and more than 540 million years of geologic history stretching back to the Cambrian explosion, when there was a massive increase in the diversity of animal life. Once a shallow sea, the layers of fossilised sand and marine life were lifted up into mountains about 250 million years ago, when the ancient continent of Cimmeria migrated from the supercontinent of Gondwana to Eurasia. Then, melting water from the surrounding glaciers formed rivers that emptied out into a floodplain bounded by forest. This eventually created a lake that became the base of the Madygen formation – and it was a lack of oxygen in the lake bed that provided such perfect conditions for fossilisation.

“It is a locality where you have a window into a distant time frame, where you have the opportunity to study different groups of animals and plants – not just individual specimens, but the system as a whole,” says Ilja Kogan at the Museum of Natural History Chemnitz in Germany. This means it could shed light on some big questions in evolution, including the conditions surrounding the Permian–Triassic extinction, the worst of Earth’s mass extinction events, which happened about 250 million years ago and eliminated 90 per cent of all species.

Working with an international team that includes scientists from Germany, Italy, Poland, Ukraine, Russia and Kyrgyzstan, Kogan is studying the vertebrates found in Madygen. They range from the weird – such as *Longisquama*, which predates the dinosaurs and was once thought to be the missing link between reptiles and birds – to the unexpected, like coelacanths, fish found only in the deep ocean today. Madygen also boasts one of the world’s largest collections of insect fossils from the Mesozoic Era – the geological time period that includes the Jurassic and Triassic. Insects are notoriously unlikely to fossilise because they are so delicate, but more than 500 species have been found here. Other researchers have pieced together the history of the area’s varied plant life, from trees to aquatic mosses; examined fossilised teeth and eggs from freshwater sharks that swam in Madygen’s ancient lake; and documented eels, molluscs and microscopic organisms called

“It could shed light on some of the big questions in evolution”

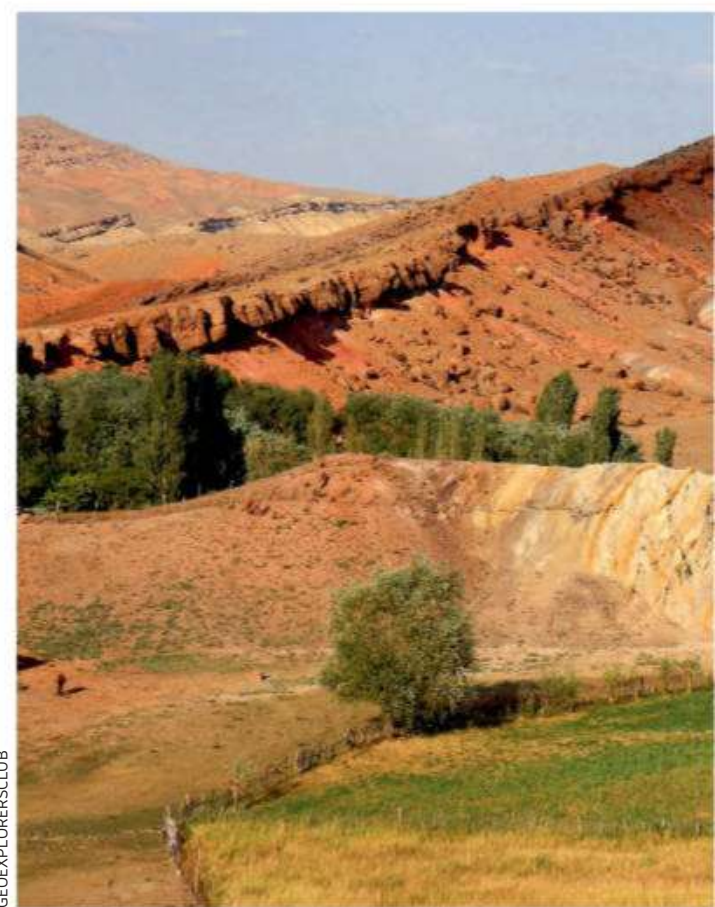
foraminifera that thrived in a shallow sea that formed here about 60 million years ago.

Despite this bounty, many local people were unaware of Madygen’s scientific importance until quite recently. “I was born and raised here, and I didn’t think there was anything to see in these hills,” says Kenesh Salyhov, a community leader from the nearby village of Samarkandyk. He changed his mind in 2021, when an academic conference brought researchers from around the world to Madygen. “I saw that they were all in awe of this park,” he says. That helped Salyhov realise that the site is special. Now, he is spearheading efforts to protect the area. Top of the list is to get Madygen recognised as a Global Geopark.

Geoparks are areas of “international geological significance” designated by

the United Nations Educational, Scientific and Cultural Organization (UNESCO) and managed by communities to help preserve their distinct landscapes while developing the local economy. Less well-known than UNESCO’s two other designations – World Heritage Sites and Biosphere Reserves, which preserve cultural and biological diversity respectively – Global Geoparks are nevertheless gaining popularity as awareness grows about their potential to draw in scientists and tourists eager to glimpse rare fossils and rock formations. There are currently 213 Geoparks in 48 countries, but none yet in central Asia. Salyhov submitted the application for Madygen late last year, and he hopes to receive a decision sometime in 2024.

Madygen has also been proposed as a potential site for a Global Boundary



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Fossils such as *Longisquama* are preserved at Madygen



Madygen dates to the Cambrian Period

Stratotype Section and Point, or “golden spike”, a reference point for the boundary between two geological time periods, because it has one of the most clearly visible boundaries between the Bashkirian Age and Moscovian Age, about 315 million years ago during the Carboniferous Period. There are some 80 golden spikes worldwide, used by geologists as reference points to study and date other rock formations. But the International Union of Geological Sciences, which makes these designations, is also considering the Ural mountains in Russia as an alternative to Madygen. That adds a political dimension to the decision, says Kogan. Kyrgyzstan has, in recent years, tried to more strongly assert its independence from its larger neighbour, which it relies on for economic support and scientific collaboration.

Building a Geopark

The bid for Geopark designation has been several years in the making. Madygen’s remote location and limited services have meant that few people even know the place exists, let alone why it needs protecting. Yet, to be recognised by UNESCO, a site must have tourist infrastructure, including trails, information signage and places to stay nearby. A lack of funding has been the main obstacle to such developments. The Kyrgyz government has shown interest in subsidising the park, but has been slow to act. So Salyhov and park staff have fulfilled these requirements entirely with volunteer labour and money from donors.

UNESCO also looks for Geoparks to serve an educational purpose. To this end, the team

behind the bid has set up a summer school in Madygen, which sees scientists and students from across Europe and central Asia visiting each August. This gives them an opportunity to gather fossils and rock specimens, says Kogan, and it helps train the next generation of researchers, including students from Kyrgyzstan, where geology departments are chronically underfunded. Research trips during the summer school have already made some significant discoveries. They have uncovered fossils of actinopterygians, or ray-finned fish, and formations from the Cretaceous Period that appear to be crayfish burrows. Isotopic analysis of shark teeth from Madygen shows that they lived in extremely fresh water, lending further support to the idea that the lake was glacier-fed.

Along with the scientific discoveries, these developments have helped attract tourists, although they are still mostly from neighbouring Uzbekistan and Russia. But designating Madygen as a Global Geopark would bring other potential benefits, including environmental ones. The Batken region, where the proposed Geopark is located, is the poorest part of Kyrgyzstan and relies heavily on damaging extractive industries like mining. Madygen contains valuable deposits of mercury, a commodity that is already being mined in nearby Aidarken. There is also brown coal, an especially polluting fuel, which many Kyrgyz people nevertheless rely on to heat their homes, particularly with the recent spike in electricity and gas prices. More tourism would provide residents with a sustainable source of income while preserving Madygen’s

unique geology from the destruction that comes with mining, says Salyhov.

Another potential benefit is geopolitical. Parts of the Madygen formation extend into Tajikistan and Uzbekistan, but borders aren’t always clearly defined and relations between these neighbouring nations have been tense lately, most recently escalating into military conflict between Kyrgyzstan and Tajikistan in 2021 and 2022. The creation of a Geopark could encourage cross-border collaboration – and there are even bigger plans in the pipeline. Discussions are under way to establish a string of Geoparks around central Asia, says Alexei Dudashvili, a geologist who runs a tour company working with the Kyrgyz government to apply for Global Geopark status in Madygen.

While they await a response from UNESCO, scientific progress continues. There is still much to be discovered, including the exact timeline of the Madygen formation. Researchers are trying to figure out exactly how many times a lake formed there during the mid-to-late Triassic and how long it lasted before drying up. They also want to better understand the climate of the region over geological time. This can be done using chemical analysis of the rocks, says Kogan.

With more fossils, researchers could paint a clearer picture of the local environment during the Triassic and into the Jurassic. However, many of the most important fossils found in Madygen over the past century are stored at the Paleontological Institute of the Russian Academy of Sciences in Moscow, and since Russia’s invasion of Ukraine in 2022, scientists are either unable or unwilling to travel there.

Despite these challenges, those pushing for Geopark status are eager to collaborate with the scientific community. Salyhov believes that the more research done at Madygen, the greater the likelihood it will receive a UNESCO designation. That, in turn, will be an important step towards reducing poverty and providing opportunities for people in his community. “Jobs will help provide for the people – they will lead tours, run guesthouses,” he says. “The tourists go to the mountains right now, but we will draw them here, to Madygen.” ■



Diana Kruzman is a freelance journalist covering science and the environment. She was based in central Asia in 2023

Dark matter's hidden depths

The mysterious stuff thought to bind galaxies together may be more complex than we thought – and now we are starting to tease apart the possibilities, says **Stuart Clark**

DELICATE might not be the first word that springs to mind when you think of the Milky Way. But when Mariangela Lisanti started tinkering with the recipe for our galaxy, she found it surprisingly fragile.

Lisanti, a particle physicist at Princeton University, was simulating what would happen if dark matter – the mysterious stuff thought to account for over 80 per cent of all the matter in the universe – was more exotic than researchers typically assume. She swapped a small fraction of standard dark matter with something more complex. “We thought, we’re only adding 5 per cent, everything will be fine,” she says. “And then we just broke the galaxy.”

There is good reason for such meddling. Since the 1980s, astronomical signs have pointed towards dark matter being a single type of slow-moving particle that doesn’t interact with itself. Particle physicists have gone to great lengths to search for that particle. But decades later, it remains a no-show – perhaps because dark matter isn’t how we have tended to imagine it.

Recently, a series of galactic anomalies has sparked a scramble to explore alternatives. This “complex” dark matter might be as simple as sub-atomic particles that bounce off each other, or as complicated as families of dark particles that form dark atoms, stars and even galaxies. There is a daunting variety of possibilities.

But now, observations of anomalies in our galaxy finally promise to help us narrow down the options. And with new telescopes on the horizon, we could be closing in on the true nature of this most mysterious substance.

Everything we know about the cosmos and how it became what it is today relies on dark matter, an idea that first captured astronomers’ attention in the 1930s. Back then, astronomer Fritz Zwicky showed that there must be more matter than the eye could see holding clusters of galaxies together. Things really firmed up in the 1960s, when Vera Rubin showed individual galaxies were rotating so quickly that they should be flying apart unless there was some form of invisible matter within them acting as gravitational glue. Then, in the 1980s, cosmologist



Jim Peebles suggested that perhaps dark matter was a sluggish collection of massive, as-yet-undiscovered particles.

Peebles's version of dark matter has proved remarkably robust – so much so that it is now essential to our understanding of the entire universe. Our best cosmological model of how the universe took the shape we see today, called Λ -CDM, postulates that the cosmos is composed of three components: ordinary matter, a still-mysterious energy called dark energy and cold dark matter. The “cold” in cold dark matter means that it is slow

moving and doesn't interact through any forces other than gravity.

This take on dark matter agrees with observations of the universe on the largest scales, which is why it has stuck around for so long. “With cosmology, [cold dark matter has] held up amazingly well,” says Lisanti. “On those scales, it's beautiful.”

But there are a few niggling problems. The most obvious one is that no signs of particles that fit this description have shown up, even after decades of searching. For a long time, a leading candidate was thought to be ➤

a kind of supersymmetric particle, which are hypothetical partners of the particles that make up regular matter. The photino, the supersymmetric partner of the ordinary photon, just so happened to be the perfect cold dark matter candidate. But the Large Hadron Collider, the particle accelerator situated at CERN near Geneva, Switzerland, which was expected to produce supersymmetric particles by the bucket load, came up empty. Not a photino in sight.

More recently, careful examination of the structure of the universe has thrown up fresh reasons to doubt cold dark matter. Models of the cosmos based on this form of dark matter may work well at the largest scales, but on the scale of individual galaxies, something seems awry: strange features are popping up to suggest that cold dark matter isn't the whole story.

Consider the missing satellites problem. Large clouds of dark matter are thought to be what attracted sufficient normal matter to coalesce and spark star and galaxy formation. As a result, every galaxy is thought to be surrounded and permeated by a sphere of dark matter, known as a halo. But theories of cold dark matter predict that instead of being uniform, every halo should have broken into many smaller sub-halos, each of which would also attract matter to form dwarf galaxies that orbit the central galaxy like satellites.

When it comes to our own galaxy, these sub-halos would contain the 60 or so dwarf galaxies going around the Milky Way. But there should be hundreds of sub-halos, and therefore dwarf galaxies – and we don't see them.

It is possible that only the largest dark matter halos drew in enough matter to form a satellite galaxy. "That gives you a very reasonable explanation of why you don't see lots of [satellite] galaxies," says Mike Boylan-Kolchin, a galaxy formation theorist at the University of Texas at Austin.

If this were the case, though, there would still be lots of these sub-halos in our backyard. "We expect them to be really dark because you just can't form stars in them," says Boylan-Kolchin. But again, we don't see them.

There is another way to detect these clumps, and to rescue cold dark matter, and that is through their influence on nearby objects. In light of this, astronomers have been turning their attention to star streams. These were once clusters of stars or small galaxies that have been cannibalised by our own galaxy, leaving them ripped apart and stretched into ribbons. Data from the European Space

Agency's Gaia spacecraft has shown that the Milky Way has captured multiple star streams. If something were to fly through them, like a dark sub-halo, it would mess them up and we should be able to detect this. "That's definitely a place where there's a concrete prediction from cold dark matter," says Lisanti.

According to the cold dark matter model, dark matter sub-halos of all sizes, right down to Earth-scale masses, should exist. That is a lot of invisible cannonballs to be floating around the Milky Way and messing with star streams. But wait for it... hardly any evidence for such interactions has been found. In 2018, Adrian Price-Whelan at Princeton and Ana Bonaca at the Harvard-Smithsonian Center for Astrophysics found that one particular star stream, known as GD-1, has gaps along its length, as if it has been hit multiple times. "It's super exciting and intriguing, but it's also still only one," says Lisanti.

The upshot is that questions about the cold dark matter model aren't going away. What's more, just recently, an even more perplexing halo-related issue, known as the core-cusp problem, has cast further doubts.

Based on our understanding of cold dark matter, simulations show halos should get denser towards the centre of the galaxy. "As you get to the centre, there should be more dark matter per unit volume," says Boylan-Kolchin. Yet, when astronomers look at the way galaxies move, which is influenced

“Dark stars could end up becoming a dark galaxy invisibly superimposed on our own”

by the gravity of dark matter, this isn't what they see. Instead, the dark matter appears evenly distributed across the halo of our galaxy, especially in the core regions. This is a hint that something more complex is going on.

As a result, some astronomers have turned towards more complicated dark matter models, which contain multiple particles and new forces of nature – under a suite of theories broadly known as complex dark matter.

We aren't short of possibilities. Some models include a mixture of cold and warm dark matter components – warm indicating faster-moving particles. Others involve self-interacting, decaying or annihilating dark matter. Weeding out this huge array of complex dark matter models is the hard part.

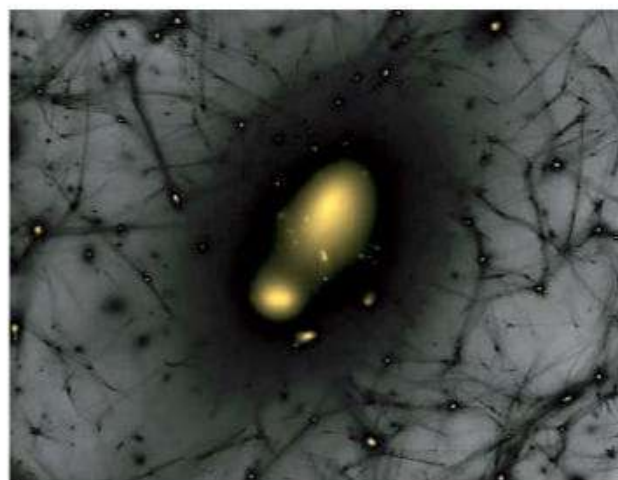
In cold dark matter scenarios, the particles



H. STOCKBRAND/RUBIN OBSERVATORY

Dark matter halos (yellow) form around galaxies

RALF KAEHLER/SLAC NATIONAL ACCELERATOR LABORATORY



only interact through gravity, but in many of these new ideas, other interactions are possible. Fast-moving dark matter particles from other parts of the halo could collide with the sluggish particles accumulating in the core, giving them more energy. This could allow them to distribute more freely, creating the kind of constant-density cores that we see.

To this end, Lisanti and her collaborators have been tweaking the recipe for galaxy formation, running computer simulations using our knowledge of how the universe evolved but modifying the behaviour of dark matter to see what might play out. And they aren't the only ones. Mark Vogelsberger at the Massachusetts Institute of Technology and Alyson Brooks at Rutgers University in New Jersey are doing similar work, testing the many possible combinations of dark matter particles and forces to find the "Goldilocks" recipe that produces galaxies like those we observe.

The trouble is that there are already so many theoretical suggestions for complex dark matter that – even with multiple teams working on it – completing simulations on them all would be impractical. "Each one of these simulations takes three or four months to run," says Lisanti. Instead, what she and her colleagues do is take characteristics or properties – such as whether the dark matter interacts with itself, decays or if its constituent particles can inhabit the same physical space as one another – and run models of particles

with the special attribute they want to test, just to see if it changes dark matter's behaviour.

It was when Lisanti and her colleagues were experimenting in this way that they found transforming just 5 per cent of cold dark matter into more complicated varieties made it impossible to form the Milky Way. "I think that was an interesting lesson," she says. "We need to be very careful when we think about new models. You don't have to add very much of [other forms of dark matter] to your models to really mess up the astrophysics."

The dark sector

In this case, the rich new array of behaviours that come from different complex dark matter models is both a blessing and a curse. When Lisanti and her colleagues allowed their particles to lose energy, they found a whole new world of possibilities. "[The dark matter] would collapse down and then we don't really know yet what all the structures are that it can form when it collapses," says Lisanti.

This is where particle physicists come in. David Curtin, a theorist at the University of Toronto, Canada, has been developing another form of supersymmetry that posits switching all matter into a twin set of particles, each with their own set of forces, rather than keeping the forces the same. This would mean twin particles can't interact with their conventional cousins through forces other than gravity – making them dark matter – but could interact with each other. "You've just predicted a complex dark sector," says Curtin.

What this means is a hypothetical complex realm in which various dark matter particles are perhaps capable of accumulating into dark atoms, and much more. Curtin calls it atomic dark matter. "Atomic dark matter [is] much like our matter; it cools, it collapses, it forms discs,

it forms stars – dark stars," he says. Since this brand of dark matter would behave in roughly the same way as normal matter, other than the fact we can't see it, that also means dark stars formed by dark atoms could end up becoming a dark galaxy invisibly superimposed on our own Milky Way.

It is a strange concept, but an invisible galaxy would have a unique fingerprint that we could see with future telescopes. If Curtin is right, dark stars will have formed a disc-like galaxy structure that will gravitationally bend light in a process called microlensing. The effect of this is to cause stars in the background to become momentarily brighter. "If you find a microlensing signal and it's concentrated in the Milky Way disc, that is a very strong indicator of atomic dark matter," he says.

In 2022, Curtin and his colleagues showed that the Vera C. Rubin Observatory in Chile could be capable of finding such microlensing signals when it begins working next year, should they exist. But he hopes to narrow down which signals would be definitive.

Many astronomers, like Boylan-Kolchin, think it is still a little premature to write cold dark matter's epitaph. "There are lots of little indications that things are at least not as simple as one might think," he says, "[but] it's not clear there's something more complicated happening in dark matter."

One alternative is that normal, non-dark matter is behaving in ways we find difficult to understand. Astronomers focus on gravity, but if we could better model thermodynamics, perhaps we would see more complex behaviour. For example, this could come from a better understanding of what happens when supernovae explode and energise surrounding gases, redistributing them through thermodynamic processes rather than gravitational ones.

In the meantime, Lisanti and her colleagues will keep running simulations to see if there could be complex dark matter in our universe. For the moment, it seems like it won't replace cold dark matter entirely. The fact that straying from current models can so easily break the galaxy shows that our existing recipe is, on the whole, working. Perhaps, then, the key to perfecting it isn't to replace a whole ingredient, but simply to add a little seasoning. ■



Stuart Clark is a *New Scientist* consultant. His latest book is *Beneath the Night*

The Vera C. Rubin Observatory, which could help find evidence for complex dark matter



Puzzles

Try our crossword, quick quiz and logic puzzle **p45**

Almost the last word

Is the evolution of intelligence inevitable? **p46**

Tom Gauld for

New Scientist
A cartoonist's take on the world **p47**

Feedback

Chocolate's big bang, plus beer glasses that keep their cool **p48**

Twisteddoodles

for New Scientist
Picturing the lighter side of life **p48**

Debunking gardening myths

A line in the sand

Digging sand or grit into clay soils is a drainage fix that has been around for years, but **James Wong** has an easier solution



James Wong is a botanist and science writer, with a particular interest in food crops, conservation and the environment. Trained at the Royal Botanic Gardens, Kew, in London, he shares his tiny flat with more than 500 houseplants. You can follow him on X and Instagram @botanygeek

I WAS one of only two kids in my Singapore state school to join the gardening club. Yes, I was deeply uncool from a very early age. After lessons each day, we had to move around great sacks of sand and dig it into the sticky clay soil under the tropical sun. We were taught by our stern teacher, Mr Lau, that this backbreaking work was necessary to help improve the drainage of dense, heavy soil, which was prone to turning into an impenetrable mass of mud in the rain and baking rock hard in the sun.

This idea dates back at least to standard horticultural advice from Victorian Britain and is still widely espoused today. Even at school, I always wondered why this never seemed to make a huge difference when the monsoon turned the whole area into one big puddle. But what does the science say?

It is true that clay soils, made of billions of tiny mineral particles, can be terrible at allowing water to pass through. The particles are packed tightly together, with little space for water and air. This is why clay soil is used to line ponds, and made into pottery. But it can have a deleterious impact on garden plants.

Sandy soils, on the other hand, have large gaps between their comparatively enormous particles, allowing water to freely pass through. So, it makes perfect sense that simply adding sand to heavy clay would give you a better soil. Indeed, sand and gravel are widely used in potting mixes for species that require fast drainage, like cacti.



VIKTOR CAPALAMY

However, when this is scaled up to the level of entire gardens, things begin to change, and this is all down to the tiny relative size of clay particles compared with sand. Anyone who has mixed potting soil will know that levels of sand have to get up to around 50 per cent before things become properly free-draining. Before this point, all that happens is that the tiny clay particles fill in the air gaps between sand grains that makes them free-draining.

At the scale of even a small garden, reaching a ratio of around 50 per cent sand would mean adding literally tens of tonnes of sand before any benefit would be observed.

Fortunately, we now know there is a much easier way to improve drainage of clay soils, by simply

mimicking what happens in nature. The action of microbial life in soil naturally creates a crumb structure, grouping fine clay particles into much larger pellets, which allow water to pass through.

These microbes feed on decaying organic matter, so all you need to boost their levels is to add large amounts of dead plant material, like fallen leaves, lawn clippings and compost. The best bit is that you don't even need to dig it in: the natural action of worms will do this for you, while they create a network of tunnels to further improve drainage at the same time. How I wish someone had told Mr Lau this in 1989. ■

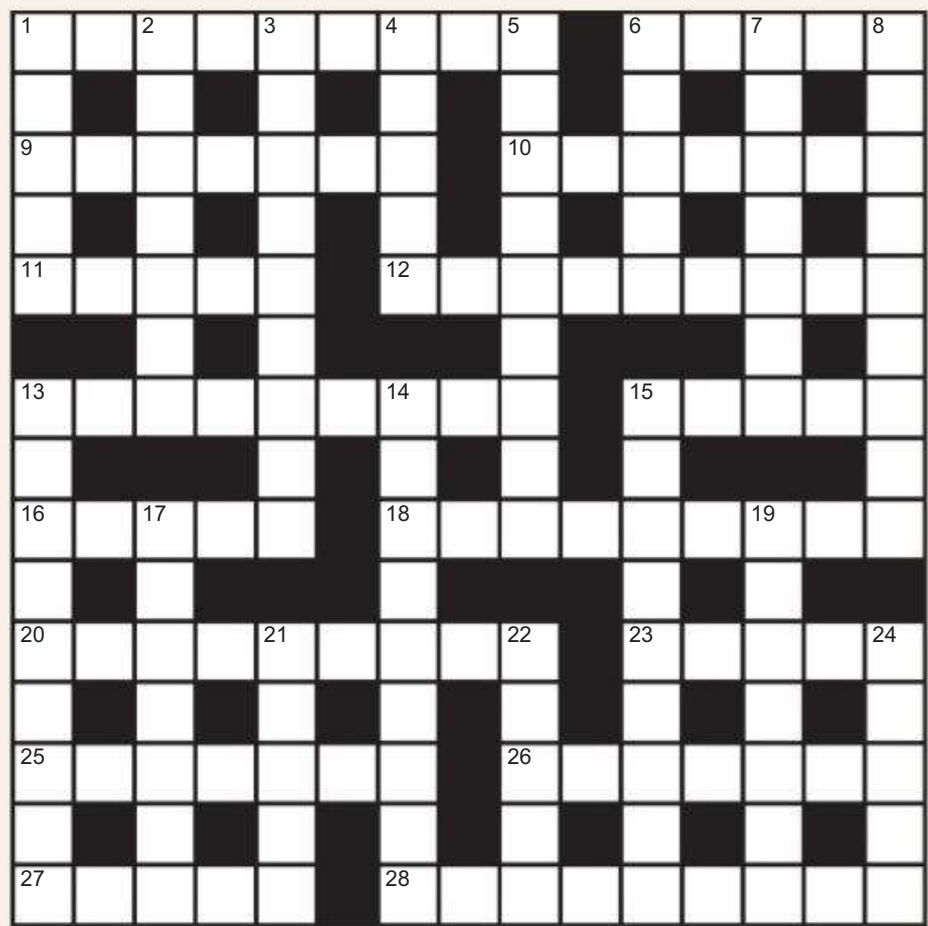
Debunking gardening myths appears every four weeks. Share your gardening successes with us on X and Instagram @newscientist, using the hashtag #NewScientistGardening

Next week

The science of baking

These articles are posted each week at [newscientist.com/maker](https://www.newscientist.com/maker)

Quick crossword #157 Set by Richard Smyth



**Scribble
zone**

Answers and
the next cryptic
crossword
next week

ACROSS

- 1** Theodore ____, Hungarian-American mathematician (3,6)
6 Gemstone, $\text{Al}_2\text{SiO}_4(\text{F,OH})_2$ (5)
9 Nb (7)
10 Rh (7)
11 Beginning (5)
12 Metal scrubbing material (5,4)
13 Battery component (9)
15 Emergency healthcare department (5)
16 Computer data store (5)
18 Disease caused by the inhalation of silica dust (9)
20 Outermost layer of the atmosphere (9)
23 Steel company formed in 1999 (5)
25 Kindle, for example (1-6)
26 Technical term for the outer skin (7)
27 Train track type (1-4)
28 Concerned with very low temperatures (9)

DOWN

- 1** Second planet from the sun (5)
2 Newborn (7)
3 Polymath of ancient Greece (9)
4 Inflammatory viral disease (5)
5 Macrophage that supports the development of its neighbours (5,4)
6 Malicious social media user (5)
7 Toxins (7)
8 Breakdown of organic substances by enzymes (9)
13 Faeces (9)
14 Concerning childbirth (9)
15 Processing for reuse (9)
17 Acute intestinal illness (7)
19 Leading figure in theatre? (7)
21 Foot lever (5)
22 Corundite (5)
24 Small tree used for spices and dyes (5)

Quick quiz #250

set by Bethan Ackerley

- 1** The white, waxy substance coating the skin of newborn babies is known as what?
2 In genetics, what does CRISPR stand for?
3 Ancient human ancestor *Homo luzonensis* is named after an island in which country?
4 Which US mathematician and computer scientist is sometimes dubbed “the father of information theory”?
5 The dispute over the naming of chemical elements 104 to 106 from the 1960s to the 1990s is sometimes known as what?

Answers on page 47

BrainTwister

set by Peter Rowlett

#18 The arithmetical two-step

You must take two steps to get from a given number to make 10. Each step must change the number by adding, subtracting, multiplying by or dividing by a number from 1 to 9. (Multiplying or dividing by 1 isn’t allowed as it doesn’t change the number.)

For example, starting with 35, one way would be to first divide by 7 then add 5.

Can you take two steps to get from 42 to 10?

Is it possible to get to 10 in two steps from all the numbers 11 to 30?

And can you find a two-digit number for which there is no way to get to 10 in two steps?

Solution next week



Our crosswords are now solvable online
[newscientist.com/crosswords](https://www.newscientist.com/crosswords)

Clever question

Once life is established, is the evolution of intelligence inevitable?

Guy Cox

Sydney, Australia

It seems pretty possible that life could arise in an environment where it would remain at the level of bacteria. They can survive almost anywhere, as they do in extreme environments on Earth, and quite possibly did on Mars. It is only when complex life forms evolve and compete for resources that intelligence becomes either possible or advantageous.

Pat French

Longdon upon Tern, Shropshire, UK

This is a difficult question to answer, as we are only aware of a single example of life emerging, found under a single set of conditions and that is defined by the subject of the enquiry, i.e. us.

Unicellular organisms existed for billions of years without much change. It would appear that the merging of two single-celled organisms to create the first multicellular organism only happened four times as far as we are aware. However, after that

“What is ‘intelligence’?

A car could be programmed to avoid all obstacles, which might look intelligent, but surely isn’t”

momentous accident, evolution accelerated and then diversified exponentially in the event known as the Cambrian explosion.

If we assume that some form of brain is required for intelligence to exist, then the answer to the question must be: no, intelligence isn’t inevitable, because single-celled life won’t necessarily evolve the required brain. The multi-cell accident may never happen.

Whether or not it is inevitable that multicellular life develops intelligence is unknowable so long



PATRICK HOFER/GETTY IMAGES

This week’s new questions

Time for bed Why do some flowers close up at night but others stay open? *Steve Child, Glossop, Derbyshire, UK*

Electric dreams Is it more environmentally friendly to keep my 23-year-old petrol car or to scrap it and buy a new electric one? I drive about 8000 kilometres a year and am quite old, so my car may outlast me. *Ian Burton, Hemel Hempstead, Hertfordshire, UK*

as only one example, under one set of conditions, is known to us.

Hillary Shaw

Newport, Shropshire, UK

Firstly, what is “intelligence”? A car could be programmed to use its sensors to avoid all obstacles, thereby protecting its owner, who maintains it. This might look “intelligent”, but surely isn’t.

Secondly, just because an attribute is useful doesn’t mean it will be created by the random mutations we call evolution: it might be useful for spiders to fly, but they don’t. Organisms are also largely ignorant of their wider environment (this seems to include many humans) and will breed up to the limits of their habitat, at which point something like intelligence may provide

a competitive edge in avoiding starvation. Or another mutation may open up a new, abundant food source. Intelligence may then be an unnecessary luxury and be lost, so have to be repeatedly re-evolved.

Alex McDowell

London, UK

Intelligence helps animals both hunt and evade predators. Hence its evolution is inevitable once animal life is established.

The inevitability of its evolution is demonstrated by the fact that it is found in humans, dolphins and octopuses, despite these animals being so distantly related. It has evolved twice in humans: Neanderthals and *Homo sapiens* both evolved to be more intelligent than their common ancestor *Homo heidelbergensis*.

Some flowers close up their petals at night – but why don’t they all do this?

Don Lim

Bangkok, Thailand

I think human intelligence is just an efficient set of biological algorithms that happens mostly through interactions of neurons. In the case of artificial intelligence, biological algorithms are re-enacted with electronic parts, such as transistor logic gates. This ensures maximum energy efficiency.

Anything that saves energy will be selected and proliferate, whether it is a physical structure of molecules or a logical process. It is the same in terms of predicting the most probable outcome and consequences in accordance with the information stored in memory. Intelligence is just a group of logical and conceptual processes, rather than a physical feature, like a wing, that evolves and gets selected for.

Once you have several intelligent individuals in a species, there might be a new pressure to outsmart them among others. This may accelerate the evolution of intelligence. We see this with companies developing artificial intelligence, which constantly have to come up with smarter models in order to survive.

In short, intelligence, just like any physical feature, saves energy and maximises the probability of survival. Therefore it is inevitable that more and more efficient information storage and processing mechanisms will take over. When these mechanisms become complex enough, they get to be called intelligence.

Will Higgs

Gilsland, Northumbria, UK

The question of the probability (and advisability!) of the development of intelligence has been succinctly addressed by the band Everything Everything. Their track *Distant Past*, warning of a post-apocalyptic return to the Stone Age, contains the immortal



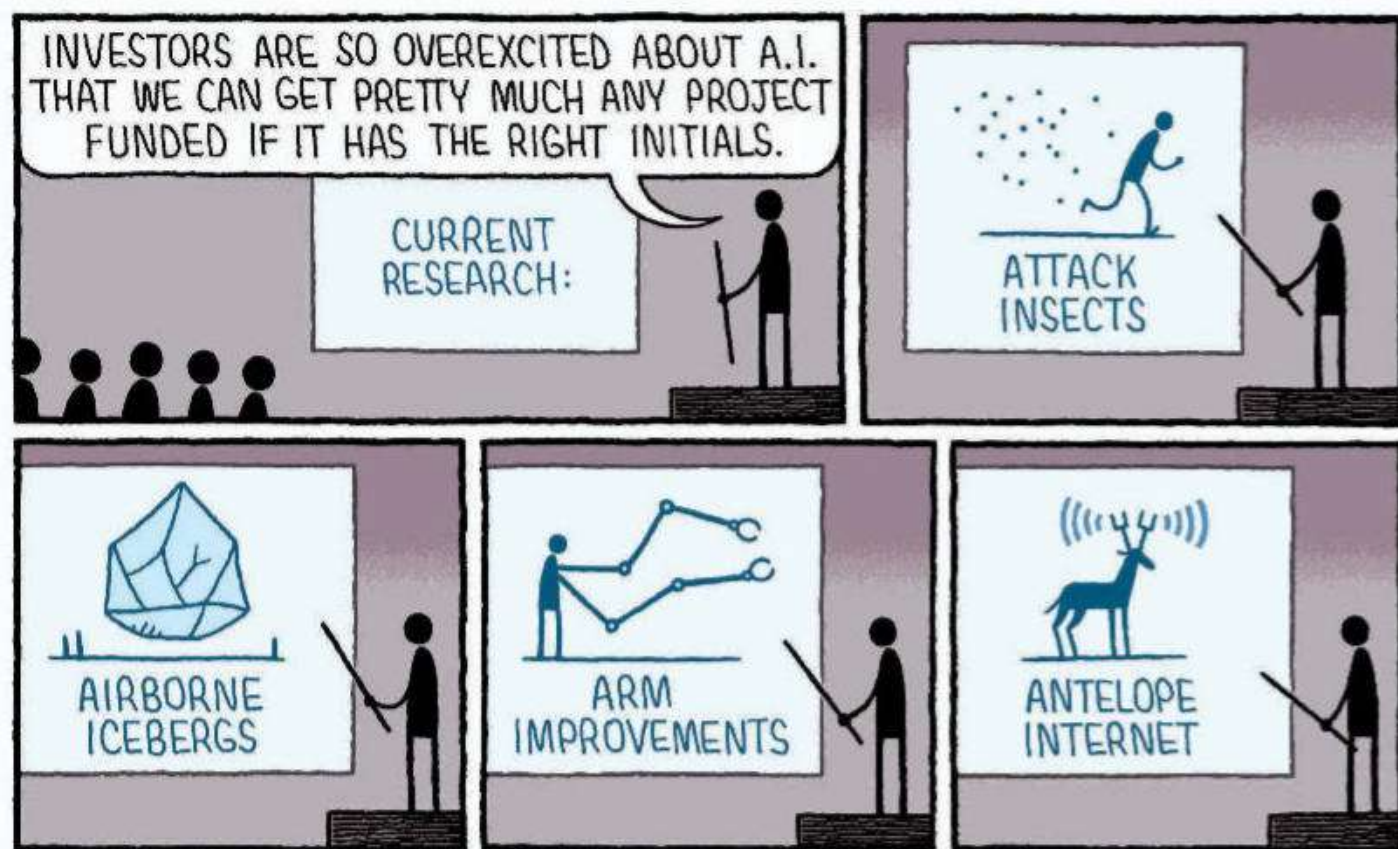
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Tom Gauld
for *New Scientist*



line: “Two thumbs, I cross the Rubicon”. In other words, an opposable thumb condemns us to destroy our environment.

Going naked

Why aren't humans covered in hair like other primates are? (continued)

Anthony Woodward

Portland, Oregon, US

David Muir's hypothesis that being almost completely hairless enabled hominins to chase down prey animals on the savannah without overheating is inconsistent with the data.

The fastest mammal on the savannah is the cheetah, which can run up to 110 kilometres per hour despite its thick coat of hair. Cheetahs evolved about 8.5 million years ago, before the human lineage split from that of the chimpanzee, about 7 million years ago. Two other mammals strut almost naked across the savannah: the elephant and the rhinoceros. Neither species races across the grassland.

“*Homo erectus*, which lived from 1.9 million years ago to around 100,000 years ago, was probably the first hairless hominin”

Hair doesn't tend to fossilise, so the exact date when hominins became hairless is uncertain, but evidence suggests that the first hominin to do so was probably *Homo erectus*, which lived from 1.9 million years ago to around 100,000 years ago. Excavations at Kanjera South in Kenya indicate that hominins were living on the grasslands there 2 million years ago. They were presumably covered with hair and certainly using stone tools consistent with hunting activities.

Trevor Campbell suggests we don't need hair because we can obtain clothes from furry animals. Our ancestors' head lice evolved into clothing lice between 170,000 and 83,000 years ago, suggesting that is when they started wearing clothes, long

after they started living naked on the savannah.

Gareth Morgan

Corfu, Greece

There is a vast amount of fossil evidence in shell middens (refuse heaps), some dating back half a million years, that our early ancestors ate a great many clams. This is unsurprising, as clams are probably the most easily acquired source of animal protein that can be harvested in large quantities.

One major drawback of relying on clams for sustenance, though, is that you would probably spend a great deal of time on the mud flats around estuaries. If you were a furry hominid, you would be almost certain to succumb to the often-fatal blood infection called leptospirosis, commonly known as mud fever or Weil's disease.

Without fur, mud on the skin would quickly dry and flake off. A naked, rapidly drying skin thus offers excellent protection against *Leptospira* bacteria, which need moisture, and would therefore be favoured by natural selection. ■

Answers

Quick quiz #250

Answers

- 1 Vernix caseosa, or vernix
- 2 Clustered regularly interspaced short palindromic repeats
- 3 The Philippines
- 4 Claude Shannon
- 5 The Transferrin Wars

Cryptic crossword

#134 Answers

ACROSS 6 Sleep lab, 8 Raku, 10 Rot, 11 Repelling, 12 Fungi, 13 Ringle, 14 Romcoms, 17 Tween, 19 Cortisone, 20 Coo, 22 Suet, 23 Whiskery

DOWN 1 ASMR, 2 Lepton, 3 Hamper, 4 Radial, 5 Tungsten, 7 Pareidolia, 9 Plane trees, 12 Forecast, 15 Murder, 16 Soothe, 18 Escher, 21 Onyx

#17 Semi-one numbers

Solution

16 is the semi-one number between 15 and 20, since 1, 10, 11, 12, 13, 14, 15 and 16 have a 1 in them. The next semi-one number is 24. There cannot be infinitely many semi-one numbers, since for numbers of more than seven digits, the proportion containing a 1 will always be more than 50 per cent (since eight out of nine first digits aren't 1, and nine out of 10 possibilities for each other digit aren't 1, the proportion of not-ones is $8/9 \times (9/10)^6 = 0.472$ for seven-digit numbers). There are in fact only 16 such numbers: 2, 16, 24, 160, 270, 272, 1456, 3398, 3418, 3420, 3422, 13120, 44686, 118096, 674934 and 1062880.

Money reunited

Chung To Kong found a way, in the spirit of unboiling an egg (Feedback, 10 September 2022), to make banknotes from shredded banknote pieces.

Kong, at the University of Hong Kong, writes: "At the Hong Kong Monetary Authority visitor center, visitors can buy a paperweight souvenir full of shredded banknotes. Even though the shredded banknotes are small, by using computer vision, it is possible to reconstruct the whole banknote like a jigsaw puzzle. Each paperweight souvenir costs \$100 HKD, and it is claimed to contain shredded banknotes equivalent to 138 complete \$1000 HKD banknotes. In theory, \$138,000 HKD can be recovered by using computer vision."

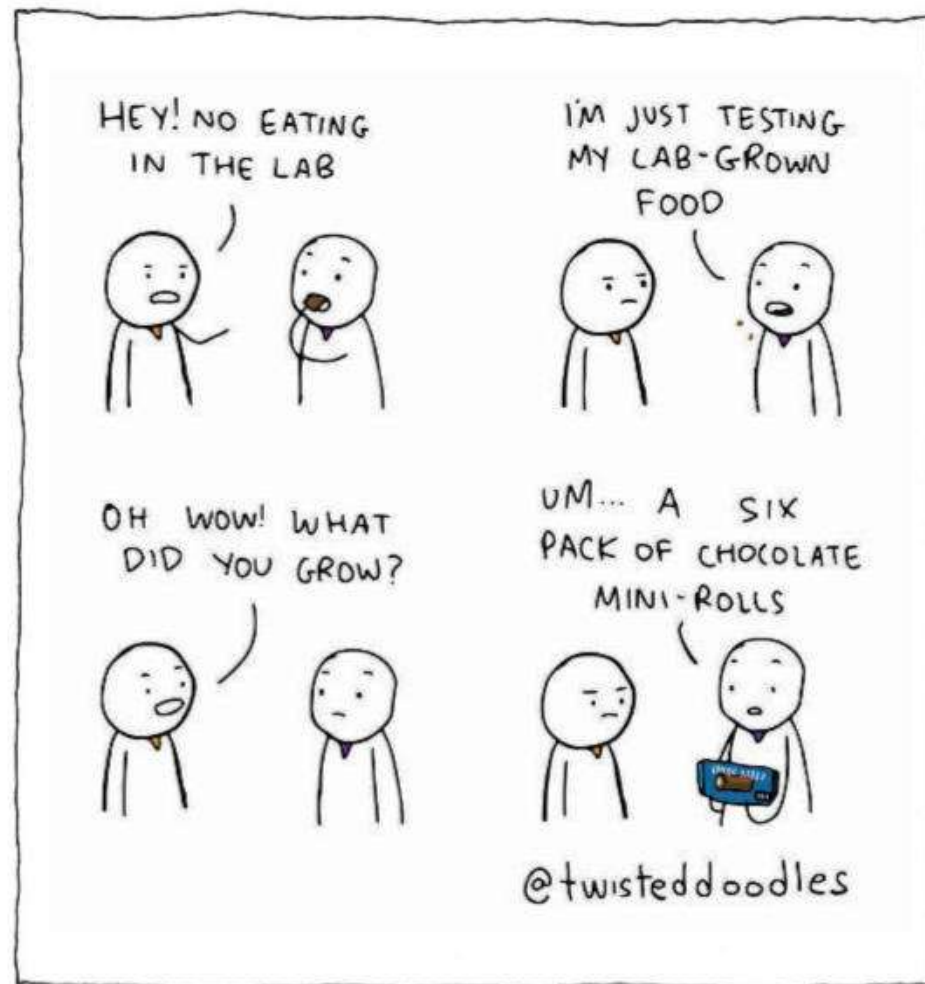
Kong visited the visitor centre, where he explained this to the staff. As a result, he says: "The paperweight souvenir is currently no longer available." Anyone who wants to make money can get details from Kong's paper, "The possibility of making \$138,000 from shredded banknote pieces using computer vision".

The big bite

Highly educated humans are trying to discern what happened in the earliest moments of two momentous events: a bite of chocolate and the birth of the universe. Maria Charalambides at Imperial College London and her team have been beaver at the bite mystery, much as many physicists have been beaver at learning what happened when the universe big-banged into existence.

Charalambides and her team's study, "A multiscale finite element analysis model for predicting the effect of micro-aeration on the fragmentation of chocolate during the first bite", is published in the *European Journal of Mechanics – A/Solids*. Their stated goal: to boldly go where no one has gone before in investigating "structures that reduce the calorific value while enhancing the taste

Twisteddoodles for New Scientist



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perception". They explored the final moment when chocolate is still fresh, before it is harshened by an encounter with digestive fluids.

Charalambides is no chocolate-is-the-entire-universe fanatic. She co-wrote the 1995 classic paper "A study of the influence of ageing on the mechanical properties of Cheddar cheese". It tells how her team dropped hunks of cheese from various heights. This produced fractured cheese and loads of data – two quantities that, if consumed individually, bring nourishment and joy to large chunks of humanity.

Feasible beer glasses

In the UK, where warm beer is either treasured or tolerated, a study called "Optimizing beer glass shapes to minimize heat transfer during consumption" might raise

eyebrows. In Brazil, where warm beer can be mildly dreaded, this is cool research. Mason Porter stoutly brought it to Feedback's attention.

The author, Cláudio de Castro Pellegrini at Federal University of São João del-Rei in Brazil, identifies two "feasible" shapes. Both, he says, "have total volumes considered high by most non-alcoholic consumers and considerably large radius of the opening, requiring a wide foot to keep balance". But he warns that "as in the case of cutting pizzas, the mathematically optimized solution to the problem may prove to be somewhat complicated to implement in practice".

237-fold gifting

For Mansi Gupta and her team, the existence of gift-giving is itself a gift to be appreciated. And analysed. Gupta is lead author on

a study called "A bibliometric analysis on gift giving", published in *Psychology & Marketing*.

Gupta, based at Lal Bahadur Shastri Institute of Management in India, and her team say that although "consumer gift-giving behavior has received much attention from marketing scholars", they decided to "conduct a bibliometric analysis of 237 articles on gift-giving". The stated main accomplishments: the paper gives readers "a state-of-the-art overview of consumer gift-giving literature and identifies opportunities for future gift-giving research".

Pivotal ketchup

The discussion of having robots use ketchup as a non-Newtonian fluid suitable for polishing glass surfaces (Feedback, 16 March 2024) prompts us to recall an earlier unexpected use of ketchup. A half-century ago, ketchup became a red-flag psychology discussion topic. Calvin Trillin later wrote about it, in the magazine *The Nation*.

Trillin observed that, prior to his forced resignation from office, US President Richard Nixon "was noted for lunching at his desk on cottage cheese with ketchup on it – a dish most Americans found so bizarre that its appeal to Nixon was used by his enemies as a comment on his character. During his second term, the White House put out the word that the President had begun to eat his cottage cheese without ketchup – presumably hoping that this information would be used by Washington commentators as evidence that Nixon had, in the phrase Washington commentators have always loved, grown in the presidency.

"That might have happened, except for one problem: Since the information on ketchup had come from the Nixon White House in his second term, nobody believed it."

Feedback would be interested to learn of other pivotal roles that ketchup has played in science or world history. Ditto brown sauce. ■

Marc Abrahams

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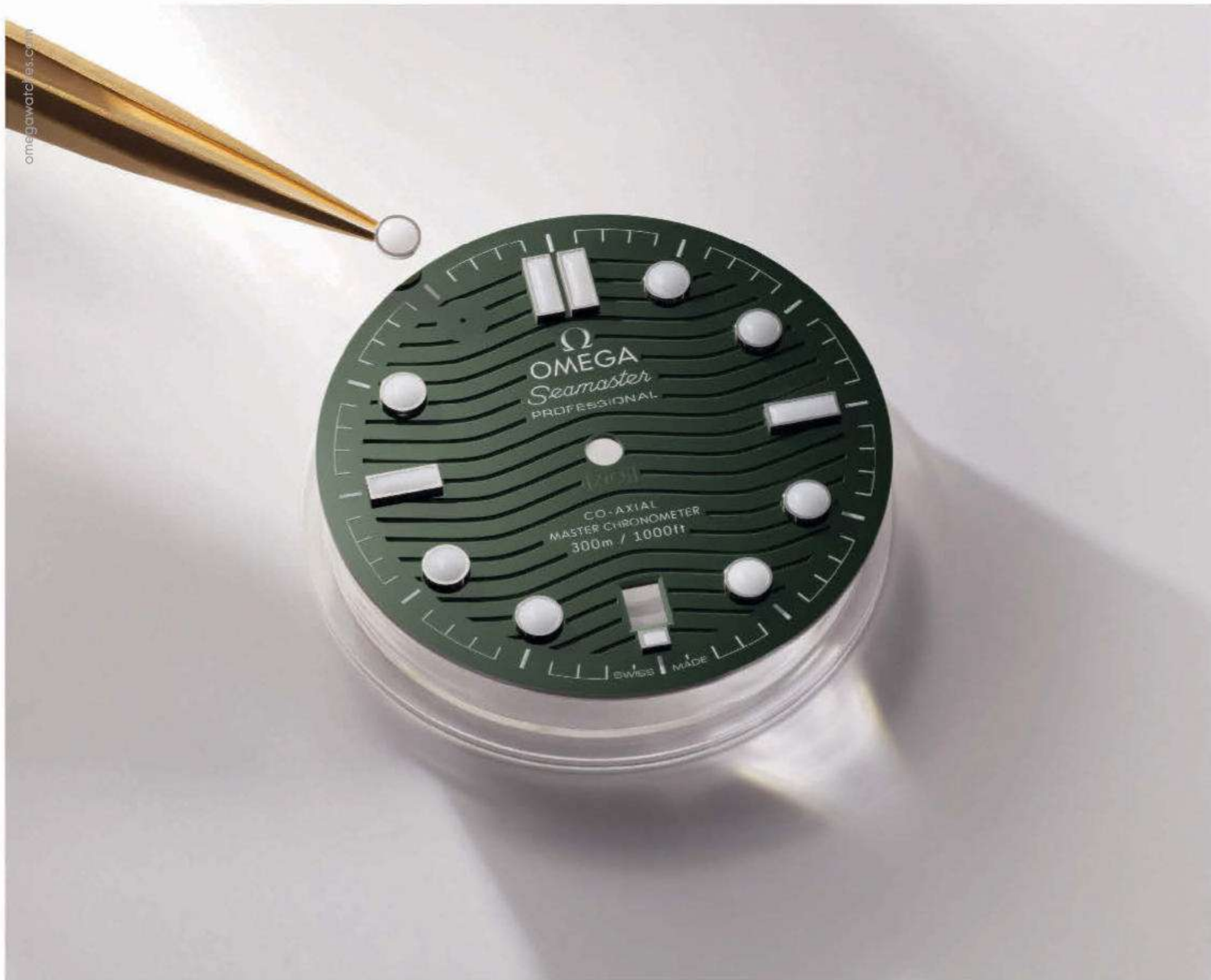
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